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FOREST PLANTING IN THE EASTERN UNITED STATES.

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OPPORTUNITIES FOR FOREST PLANTING.

Nearly every farm includes one or more pieces of land which can be more profitably planted to timber than to an agricultural crop. Such an area may be some small corner not easily accessible, or else a piece of poor, sandy, swampy, or worn-out land, or it may be an old woodlot in poor condition and not fully stocked with growing timber.

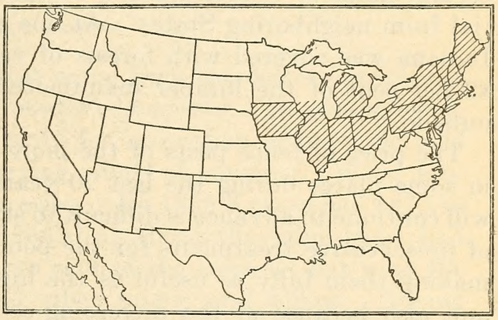

Fig. 1.—Sketch map of the United States, the shaded area showing section studied in this bulletin.

The 1910 census shows that the average farm in the United States contains 138 acres, of which 75 are recorded as improved and 63 as unimproved, the latter consisting of "woodland" and "all other unimproved land."[1] The woodland and other unimproved land covers the enormous total area of 400,346,000 acres. Of this nearly 245,000,000 acres are in the States east of Texas and the Rocky Mountains, about 175,000,000 acres of which are in woodlots. There remain about 70,000,000 acres of unforested and unimproved land in this eastern portion of the country, most of it best suited for growing timber. This area will be reduced by draining the swamp lands potentially adapted to agricultural crops, but will be increased by the addition of lands becoming worn out and unfit for growing field crops.

Since 1870 in New England the proportion of improved farm land has gradually declined as follows: In 1870, 61.3 per cent; in 1880,

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[1] "Woodland" includes all land covered with natural or planted forest trees which produce, or later may produce, firewood or other forest products. "All other unimproved lands" includes brush land, rough or stony land, swampy land, and any other not improved or in forest.

Note.—This bulletin is of interest to landowners throughout the northeastern United States, as shown by the shaded portion of the sketch map on this page.

61.2 per cent; in 1890, 54.4 per cent; in 1900, 39.6 per cent; in 1910, 36.8 per cent. These figures indicate a tendency to discontinue the use of land for purposes for which it is unfitted. Most of the unimproved farm land in the East and the Middle West is best suited to the growing of timber. Conditions in this region, moreover, are particularly favorable for fire protection, intensive management, and a maximum yield.

Timber brings the highest price, of course, where the natural supply is becoming scarce. In 1900 the average value of sawlogs in the United States was $6.28 per thousand feet, board measure; in Iowa, Indiana, and Ohio it was $12.16, $9.39, and $9.47, respectively. The higher prices in these States were due partly to local scarcity and partly to the fact that the timber consisted almost entirely of the more valuable hardwoods.

Lumber is manufactured usually in the locality of the standing timber. Wood-manufacturing plants in some States formerly rich in certain kinds of timber are now compelled to obtain their raw material from neighboring States. At one time four-fifths of the area of Indiana was covered with forests of valuable hardwoods. In 1900, 82 per cent of the lumber manufactured in that State came from outside.

The price of fence posts of the more valuable species has doubled in some places during the last 20 years. To what extent the price will continue to advance is difficult to say, because of the introduction of preservative treatments for the poorer, cheaper kinds of timbers, making them fully as useful as the higher grade timbers untreated, and also because of the increasing use of concrete posts. Wooden posts will always be needed for temporary fences, however, and many farmers will undoubtedly always prefer them for permanent ones because of their light weight. A farm of 160 acres requires annually 75 to 100 posts for the repair of fences and often additional ones for temporary fences. A small plantation of trees suitable for fence posts appears, then, to be a very desirable farm asset.

Another class of forest products for a timber plantation is that of cordwood for domestic use and for sale. The annual consumption of cordwood in the United States to-day is about 86,000,000 cords.[1] In large cities—those of 30,000 inhabitants or more—at the present day, the average value of firewood is about $7 per cord, and in cities of 1,000 to 30,000 population this value averages about $4 per cord.

A number of the States, through demonstration areas and the distribution of stock free of charge or at cost, are taking active steps to encourage forest planting. Sixteen States [2] have sought further to induce planting by systems of tax exemptions, bounties, or prizes. Such provisions, however, have not always been carefully drawn. In some cases the application of the law has been restricted to a certain list of trees from which valuable species well adapted to planting have been omitted; the number of trees per acre specified for planting and the regulations regarding thinnings have not always been drawn in accordance with scientific principles of forestry; the period of exemption, or bounties, has sometimes been too short, applying only when the trees are small and the taxes on them normally light. Assessors, moreover, have sometimes adopted the practice of adding enough to the assessment of some other property of the timber owner to make up for the reduction on his plantation. Laws of this kind, however, even though they may have shown little in the way of results, indicate a willingness on the part of the various States to encourage forest planting.

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[1] Forest Service Circular 181.

[2] Alabama, Connecticut, Illinois, Iowa, Kansas, Massachusetts, Maine, Minnesota, Nebraska, New Hampshire, North Dakota, Rhode Island, Vermont, Washington, Wisconsin, Wyoming.

STATUS OF FOREST PLANTING IN THE REGION.

PRAIRIE REGION.

The settlers in the prairie region came from wooded countries and knew the value of trees for protective purposes. In consequence, they planted timber trees primarily for protection against the cold winds of winter and the hot, drying winds of summer. Wood production was a secondary consideration. By 1885 Kansas had 147,340 acres of forest plantation, and Iowa, at about the same time, had 100,000 acres. From 50 to 75 per cent of the trees set out were the hardy, rapid-growing cottonwood, silver maple, and willow. Among the other species represented were green ash, black walnut, butternut, balsam fir, European larch, Norway spruce, white spruce, black cherry, arborvitæ, red cedar, Scotch pine, white pine, black locust, osage orange, honey locust, and hardy catalpa. In one portion or another of the prairie region each of these species has found conditions favorable for growth.

However, the hardwoods that were most generally planted are not so good for windbreak purposes as are the conifers, which retain their foliage through the winter. Because of this fact, and also because many of the older plantations are maturing, the latter are now being removed. Much of the land they have occupied is worth from $100 to $150 or more per acre when put in agricultural crops. For this reason forest planting is no longer being carried on to anything like the extent it once was, though extravagant claims made for hardy catalpa by certain tree agents have resulted in a considerable quantity of this species being set out recently for post and pole production.

As the old plantations are cut and the need is felt for new windbreaks to take their place, trees will be planted for this purpose. White pine, Norway spruce, and white spruce are likely to be the favorite species. There will be some planting to provide shade for stock and to grow fence posts and other products for use on the farm. Such plantations, however, will be restricted to the less valuable land, and their extent will depend very largely on the success of those already established.

In some of the more newly settled districts, as yet practically treeless, planting of the rapid-growing hardwoods is still going on, and will probably continue for some time.

CENTRAL HARDWOOD REGION.

The central hardwood region comprises Ohio, Indiana, Kentucky, and southern Michigan. Thus far very little planting has been done in any of these States. When the settlers in Iowa, Nebraska, and Kansas were setting out trees, the men of the central region were engaged in clearing their land of one of the finest hardwood forests in the world, which stood as a barrier against agricultural development.

Within the past 5 or 10 years, however, forest planting has received a stimulus through the activities of State forest officers, and also through the distribution by some of the States, either free or at cost, of forest-tree seedlings raised in State nurseries. By 1910 Ohio had distributed more than 1,000,000 of such seedlings, and in 1907 and 1908 Michigan distributed 396,000. Indiana and Michigan have State demonstration areas where different species are planted experimentally.

As the soil in portions of the hardwood regions deteriorates under cultivation, larger and larger areas will find their best use in the production of timber. In Indiana alone some 6,000,000 acres are at present unproductive. The chief purpose of planting will probably be to secure fence posts, handle material, and other products which can be grown in a comparatively short time. At present the species most widely planted are black locust and hardy catalpa. Others being set out include white ash, white, Scotch, and western yellow pine, yellow poplar, various oaks, European larch, Norway spruce, chestnut, and black walnut.

NORTHEAST REGION.

Early conditions in the northeast region, comprising Pennsylvania, New Jersey, New York, and the New England States, were much the same as in the central hardwood region. There was an abundance of natural timber which was gradually removed with the development of agriculture. Yet the first experiments in forest planting in

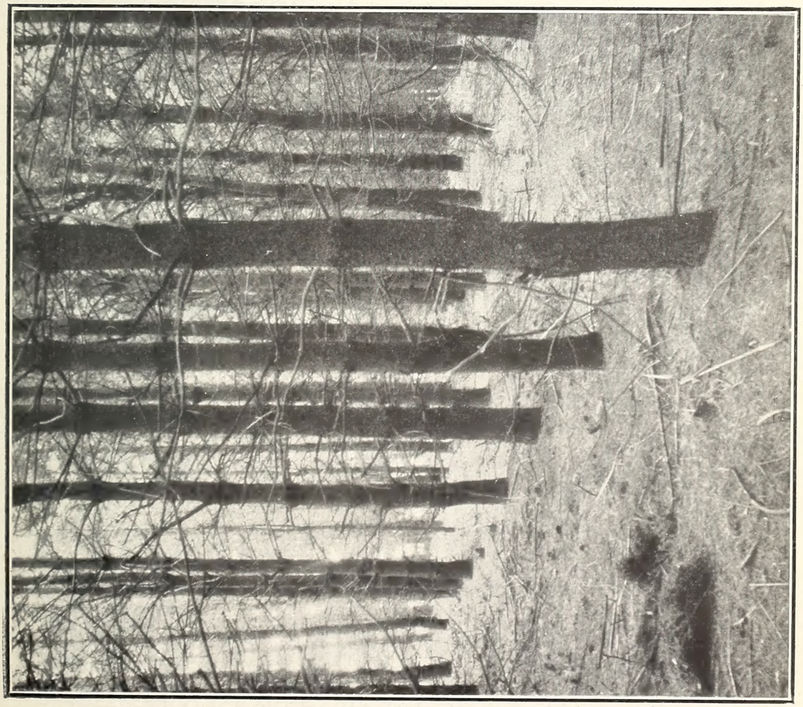

FIG. 1.—WHITE PINE PLANTATION, CENTRAL IOWA, 37 YEARS OLD, SPACED 8 BY 9 FEET. WHITE PINE GROWS WELL HERE.

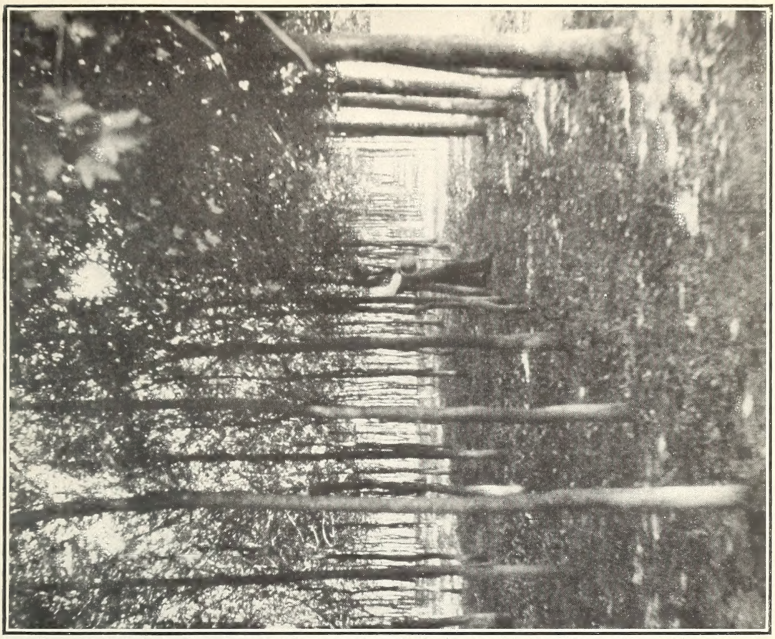

FIG. 2.—MIXED PLANTATION OF OAK, ASH, ELM, AND MAPLE, INDIANA, 15 YEARS OLD, USED AS A WINDBREAK.

the United States were made in New England. One of the earliest plantations of which there is record was set out in 1819 near Chelmsford, Mass., when the Rev. J. L. Russell transplanted a large number of pitch-pine seedlings from a field he wished to cultivate to a stretch of barren drift sand. In 20 years he had a fine stand of pine from 6 to 8 inches in diameter. In 1820 Zacharias Allen planted about 40 acres of waste land at Smithfield, R. I., with oak, hickory, and locust. A careful account of all expenditures and receipts was kept, and at the end of 57 years the books showed a profit of 6.92 per cent on the capital invested.

Present-day conditions in New England well illustrate the principle that in older communities the size of the farm reflects the potential value of the soil for agricultural crops. The poorer the soil the larger will be the individual farm and the less intensive the cultivation. Thus in the period between 1850 and 1910 the size of the average farm in Maine increased from 97.2 to 104.9 acres; in Vermont, from 138.6 to 142.6 acres; and in New Hampshire, from 116 to 120.1 acres; while during the same period the average farm in Ohio decreased from 125 to 88.6 acres; in Indiana, from 136.2 to 98.8 acres; and in Illinois, from 158 to 129.1 acres.

In the States with the poorer soils, as indicated by the increasing size of the average farm, forest planting by private owners may be expected to increase. Of the approximately 10,000,000 acres of abandoned farm lands, 1,000,000 acres are in New Hampshire, and large areas lie within the other New England States. On most of these lands natural reforestation is slow, except in the case of inferior species, such as gray birch. White pine is the tree being planted most in New England. Though admirably adapted to the region, it is subject to serious damage by the white pine weevil (*Pissodes strobi*), and for this reason some other species, possibly Norway pine, may to some extent take its place in future planting. The eastern region is adapted to the growth of any of the northern hardwoods or conifers, and the choice of species will depend largely upon the relative rate of growth and the value of the products which it is possible to obtain. Massachusetts, Vermont, New Hampshire, Connecticut, and New York all distribute tree seedlings. In 1910 the demand by private owners in New York for State-grown white pine transplants amounted to nine times the supply available for distribution. Massachusetts, Connecticut, and New York also maintain State demonstration areas. Because of the relatively large proportion of wornout land the eastern region offers exceptional opportunities for forest planting. As a matter of fact, forest planting as a commercial enterprise is being more widely agitated in New England to-day than anywhere else in the United States.

ESTABLISHMENT OF PLANTATIONS.

NURSERY STOCK.

In choosing planting stock the planting site and the probable care of the growing seedlings must be taken into account. With hardwood trees, such as ash, maple, locust, or catalpa, 1-year-old stock is suitable. It costs less, is cheaper to plant, and is just as likely to thrive as older stock.

With coniferous trees, such as pine or spruce, 2-year-old seedlings or transplants or 3-year-old transplants are best. Transplant stock of conifers, when 2 or 3 years old, has a more fibrous and better developed root system than corresponding seedling stock, and is more likely to succeed than the latter, especially under unfavorable conditions. Transplant stock should always be used on heavy soils where for any reason cultivation is impossible and the young trees must compete with a heavy growth of grass. This would apply, for example, to cut-over areas filled with roots of old trees and to very steep slopes.

Tree seedlings, especially of hardwoods, can be raised on a farm at low cost and with almost as little trouble as a bed of vegetables. The seed may be purchased or collected locally and planted in drills in soil prepared in the same manner as for vegetable crops. Stocks thus raised can be left in the seedbed until it is convenient for the owner to plant it. This plan avoids possible damage to the stock during shipment from a commercial nursery or unforeseen delays in planting the stock after it is received. One-year-old hardwood stock varies in height from less than a foot to more than 4 feet. A tree's height growth during the first year usually indicates its future vitality. Thus the taller trees grown in the seedbed should be given preference in planting. In the case of a plantation of black locust in Indiana, where the planting stock was raised by the owner, the smaller stuff was about 3 feet and the larger 7 feet tall after two years' growth in the seedbed. The larger and smaller trees were planted separately on similar sites. After four years the 7-foot seedlings were 20 feet high, while the 3-foot seedlings were only 12 feet high.

Advantage could be taken of this characteristic by planting the more and the less vigorous trees in mixture, the shorter ones merely as fillers to be cut out when the stand becomes crowded, the taller trees to constitute the stand to be left until maturity.

Conifers are not so easily propagated as hardwoods, and it would ordinarily be best to purchase coniferous seedlings or transplants rather than raise the stock at home. Conifer stock should be purchased either from reputable nurserymen or from those State nurseries which offer it for sale. If a fairly large number of young plants are desired, it is usually possible to obtain them at a reduced price if a contract is made with the nurseryman some time in advance. Lists of dealers in nursery stock may be secured from the Forest Service, Washington, D. C. Stock from local nurseries is usually preferable to that secured from a distance.

METHOD OF PLANTING.

FACTORS DETERMINING CHOICE OF METHOD.

The cost of the actual planting operation is one of the fundamental factors in fixing the final cost of the plantation, and so the method to be followed in this operation should be given careful consideration. What method should be applied depends upon the species and size of stock, character of site, condition of stock, and region.

If for any reason large stock with large root systems must be planted, such as hardwoods 2 or more years old or conifers several years old, holes must be dug either with a spade or mattock for each individual tree. But if smaller stock can be used a more rapid, cheaper method may be followed.

The character of the species alone may be the single factor in determining the method of planting. For example, the nut trees develop so deep a tap root that it is impracticable with them to adopt any method of planting except that of sowing the seed directly on the permanent site.

The character of the site alone may also determine the planting method. A very rocky situation may preclude all planting methods except that of digging a hole for each individual tree.

The condition of the particular stock to be planted may make one method preferable to another. If, for instance, the trees are received in poor condition, or if they happen to have a very poor root system, it may be necessary to plant them with particular care.

The region, together with the species, is an important factor in determining the planting method. The climate in one region may favor a given species more than that in another region, and hence more rapid, less careful methods of planting may be used in one region than in another.

DESCRIPTION OF METHODS.

Slit method.—The planting method which has probably been most often used is that known as the "slit method." A wedge-shaped hole is opened in the ground by inserting a spade and moving it backward and forward. The roots of the seedling or transplant are then inserted back of the spade in the cleft thus formed, the spade is removed, and the earth pressed with the foot firmly around the plant. A mattock is sometimes used instead of a spade. With this the soil may be loosened over a spot from 10 to 12 inches in diameter, and the cleft then made in the center of this loosened soil.

The slit method has proved very successful throughout the region of this report, both with hardwoods and with conifers.

Direct seeding.—The method of direct sowing of seed in rows on the planting site has been followed with much success. In a few cases walnut seed which during the previous winter had not been properly prepared by stratifying was sown in the spring with rather unsatisfactory results. A portion of the seed sprouted the first summer, but the larger part of it remained dormant in the soil through the following winter and then sprouted. Such cases as this merely emphasize the need for treating such seed before planting it.

Broadcast sowing also deserves some attention. In Iowa one plantation of green ash was started by broadcasting the seeds on ground prepared by plowing and harrowing and then covered by harrowing. The trees came up very thickly; after 17 years a sample plot 50 feet square showed 135 living and 63 dead trees. Ordinarily such good results could not be expected, but these figures show that a very dense stand may sometimes be secured by broadcast sowing. Similar results might be obtained with species other than green ash, but success is not as likely as in the case of other methods of sowing or planting.

Planting of sprouted nuts.—A rather novel but very successful method of planting black walnut was that followed by one planter in Indiana. He buried the walnuts in a shallow pit during the winter so that they might be subjected to the action of frost and moisture before planting. Upon uncovering the nuts the following spring he found that many of them had formed sprouts 3 or 4 inches long. These were planted on well-tilled ground by scooping out a little soil with the hands, a method similar to that of planting cabbage. This method reduces the possibility of fail places in a plantation, and may be used with species like black walnut, butternut, hickories, and oaks, wherever the nuts sprout before the planter is able to set them out. Sprouting does not in the least injure the quality of the seed, although it may necessitate such a method of planting as the one described.

Furrow method.—Another method is to plant young trees in a plowed furrow. This is rapid, and in good soil has proved successful with such hardwood trees as cottonwood, maple, and ash, and also with such coniferous trees as pine and spruce. It is especially applicable in the case of cottonwood and willow cuttings of 1 or 2 year old wood taken from old trees.

Individual hole method.—This method, which has not been used extensively, consists simply of digging a hole for each individual tree. It is undoubtedly the surest method, but at the same time the most expensive.

COSTS OF DIFFERENT METHODS.

Table 1 shows the cost of planting operations, exclusive of the cost of the stock itself, where different species and methods were used.

TABLE 1.—*Cost of planting with different species and methods.*

Case No.	Species.	Stock.	Method of planting.	Soil.	Cost per M.
1	Black locust	1-year seedlings	Holes dug	Yellow clay silt	$5.35
2	do	do	Slit method	Sand	1.25
3	Russian mulberry	do	do	Yellow clay silt	3.00
4	do	do	do	Sand	1.50
5	White pine	Wild stock 5 to 6 inches high.	Holes dug	Black loam	6.00
6	do	Seedlings	do	do	5.00
7	do	3-year seedlings	Slit method	do	3.00
8	do	1-year transplants	do	Yellow clay silt	3.00
9	do	2-year seedlings	Furrow plowed	Black loam	1.25
10	Black walnut	Seed	Small hole dug	do	1.00
11	do	do	Dropped in intersections made by corn marker.	do	.75
12	do	do	Pressed into ground	do	.50
13	do	do	Dropped into old corn hills.	do	.50
14	do	Seed, sprouted	Like cabbage plants	Black sandy loam	5.50
15	do	Seed	Furrow plowed	do	.50
16	White ash	3-year seedlings 6 to 8 feet tall.	Holes dug	Sand	7.85
17	do	1-year seedlings	Slit method	Black loam	2.00
18	do	do	do	Sand	2.00
19	do	do	do	do	1.50
20	do	do	Furrow	Black loam	2.00
21	Green ash	do	Slit method	do	1.00
22	do	Seed	Broadcast	Yellow clay loam	.50
23	Cottonwood	1-year seedlings	Slit method	Sand	1.50
24	do	Cuttings	Furrow	Black loam	.25
25	Norway spruce	2-year transplants	Holes dug	do	6.00
26	European larch	2-year seedlings	do	do	5.00
27	do	do	Slit method	do	3.00
28	do	do	do	do	1.00
29	Scotch pine	Seedlings	Holes dug	do	5.00
30	do	2-year seedlings	Slit method	do	3.00
31	do	4-year transplants	Furrow plowed	do	3.00
32	Soft maple	1-year seedlings	do	do	2.00
33	do	Seed	Hoe	do	.35
34	Bur oak	do	do	do	.35
35	White spruce	1-year transplants	Furrow	do	1.25

Table 1 is based largely on estimates of cost made by actual planters. Since in most cases no exact records were kept the figures are only approximate, though they show very closely the relative costs of the different methods of planting. In order of cheapness the four principal methods rank as follows: Direct sowing of seed; planting in furrow; slit method; digging a hole for each tree. Apparent discrepancies in the table are due to the special conditions of each case, such as topography and soil, and the care exercised by individual planters.

MERITS OF THE DIFFERENT METHODS.

For those species to which it is adapted, direct sowing has the advantages of rapidity and cheapness. On the other hand, the seed may be eaten by birds or rodents, or it may be defective. Again, the small size of the trees during the first year makes proper cultivation difficult, nor can the method be relied upon in unfavorable sites or seasons. In spite of these objections, however, it has proved successful with walnut, butternut, ash, silver maple, red and bur oaks, black cherry, and white, Scotch, red, and pitch pines.

The seed of the nut trees (walnut, butternut, the hickories, and black and red oaks) should either be planted in the autumn or, what is better, buried in a shallow, rodent-proof pit out of doors during the winter, and then planted on the permanent site in the following spring. Seed thus buried during winter is said to be "stratified." Silver maple seed must be gathered during the spring in which it is planted. Seed of the remaining species mentioned in the preceding paragraph should be gathered during the fall or winter previous to planting and stored away until spring. Pine seed is best stored in a sealed fruit jar or other air-tight container, though it, and also cherry seed, may be stored in cloth sacks hung out of the reach of rodents in a cool, well-ventilated room. Stables, however, should not be used for storage purposes. Ash seed is best stored with an equal volume of moist sand in boxes kept in some cool place.

Planting in furrows is rapid and is the least expensive of all methods for seedlings, transplants, or cuttings. It has proved successful with both hardwoods and conifers, but there is danger that the trees will not be set deeply enough in the ground. The method of covering the roots—simply plowing a second furrow toward them—is very likely to result in either covering the young trees or leaving the roots exposed. Frequently the earth is not well firmed over the roots, though this may be done after the plow has passed. The method can be practiced, of course, only where the ground permits of plowing. Because of its low cost it is recommended, if carefully done, for small seedlings or transplants without a pronounced taproot system, on good soil, and also for cottonwood and willow when propagated by cuttings.

The slit method of planting has proved very successful, and is fairly rapid and cheap. It may be recommended for small stock of nearly all species unless the soil is very poor or uncommonly dry at the time of planting, or unless the stock used is exceptionally high priced or in poor condition.

Digging a hole for each tree is necessary under such conditions as those just cited. This is an expensive operation, however, and should not be used where any other method would prove successful. In case 16 in Table 1 the stock used consisted of 3-year-old seedlings between 6 and 8 feet tall. As compared with the other cases the cost of planting was very high. The soil was almost a pure sand, which made digging easy, but a hole 2 feet deep had to be dug for each tree. The trees grew so poorly at first that after a couple of years the owner cut them back to the ground. Sprouts have come up from the stumps, but these are only a little larger than some 1-year-old seedlings set out three years later on the same site. Large stock is only to be recommended where hogs are to run among the trees soon after planting.

TIME OF PLANTING.

Practically all of the plantations examined in the region have been started in the spring, which seems the best season for setting out seedlings on the permanent site. As compared with autumn planting, spring planting has at least two distinct advantages—the stock has a whole growing season in which to become established before being subjected to the rigors of winter, and it is not subject to the immediate danger of being heaved out of the ground by alternate freezing and thawing. On the other hand, a dry season immediately after the trees are set out in the spring may prove fatal to the plantation.

In the case of direct sowing, the time of planting is best determined by some characteristic of the seed to be planted, particularly the time of ripening. Silver maple and elm seed, for example, lose their vitality soon after they ripen in the spring and must be sown at the latter time. Walnut, butternut, hickory nuts, and red oak seed must be kept moist for a considerable period before they will germinate well; hence they must either be planted in the autumn or else stored over winter in some place where they will come in contact with damp soil. Any freezing which occurs during this period will be helpful in opening the hard shells.

Cloudy days should be selected for planting, especially in the case of conifers. Exposure to the sun, even for a short time, will kill the young roots, and thus the plantation will fail at the very start. The roots of the young trees, whether hardwoods or conifers, should be kept moist up to the very moment when they are planted on the permanent site. The stock may be carried to the field in a bucket, with the roots immersed in water, or the roots of a bunch of trees may be wrapped in wet burlap, one tree being drawn out at a time and planted.

PREPARATION OF THE SOIL.

Plowing and harrowing the planting site before setting out the trees is a wise practice. It puts the soil in good tilth, facilitates planting, conserves soil moisture, increases the proportion of successful trees, and induces rapid initial growth. On very sandy soils which do not support a heavy sod of grass, however, preparation is not necessary; and on very steep slopes and among rocks or large roots may be too expensive.

Fall seems to be the best time to prepare the ground, since the soil is thus exposed to the action of the winter frost, and has time to settle before receiving the young trees. The trees in a 5-year-old plantation of black locust in southern Michigan, on fall-plowed ground, were fully as large as those in a 6-year-old plantation set on an adjoining strip plowed in the spring.

SPACING.

The proper spacing for trees in a plantation depends largely on the habit of the species and the character of the site. In general, the more tolerant the trees and the more unfavorable the site the closer should be the spacing. White pine is so tolerant that it must be planted as closely as 4 by 4 feet, in order to have the lower branches killed by shading at an early age. Close-spaced stands must be thinned sooner than open-spaced ones, and if the owner does not intend to make such a thinning when needed he should use a wider spacing. With practically all species close spacing requires a thinning before the stand is 20 years old, and in the case of some, especially intolerant or rapid-growing trees, such as cottonwood, by the time it is 10 years old. The trees removed in the early thinnings required by close spacing would usually be unmerchantable; hence, if the site is favorable, a wider spacing is usually best. Wide spacing, moreover, reduces initial cost and will give larger trees than can be grown in the same time in a closely spaced plantation in which early thinnings are not made.

On the less favorable sites, however, close spacing is best. The greater number of trees per acre offsets the higher mortality among the young plants on poor situations and also gives a thicker crown cover, and hence better protection of the soil. The relatively large amount of falling leaves and litter, moreover, mixes with the soil, thus actually improving it.

Close spacing gives clearer but comparatively slender boled trees; wide spacing results in more or less branchy trees of comparatively large diameter. This is well illustrated in the case of two plantations of white pine near Clermont, Iowa, on very similar sites. In one of them the trees were originally spaced 1 by 6½ feet and in the other 16 by 16 feet. When 43 years old the trees planted 1 by 6½ feet had reached an average diameter of 7½ inches and an average height of 53 feet; the lower branches were dead to a height of from 20 to 30 feet and were falling off. At the same age the trees planted 16 by 16 feet had reached an average diameter of 12.3 inches and an average height of 60 feet, and though the lower branches were dead to a height of from 20 to 30 feet they were still persisting. Of two plantations of European larch near Sac City, Iowa, on similar sites, one spaced 8 by 8 feet has, after 28 years, reached an average diameter of 7.6 inches and a height of 47 feet, with the lower branches dead to a height of from 20 to 30 feet. The other, spaced 10 by 12 feet, at the same age shows an average tree diameter of 9.2 inches and a height of 43 feet, the trees having been pruned artificially to a height of 20 feet.

Old plantations have done much to indicate the relative spacings to which different species are adapted. These spacings are given under the discussions of the respective species.

CARE OF PLANTATIONS.

CULTIVATION.

Most forest plantations should be cultivated for two or three years after being set out. On the heavy soils of the treeless and hardwood regions cultivation becomes almost necessary. Though even on these latter soils the trees will survive without cultivation, they take a number of years to become well established, and meantime make very little height growth. If cultivated, however, they become well established during the first or second season and grow vigorously in height during this time. This contrast is brought out by two plantations of green ash, one in Iowa and one in Ohio. The soils in the two regions, though somewhat different in character, are both conducive to the growth of the species. In the Iowa plantation the trees were well cultivated and had reached an average height of 9 to 10 feet when only 4 years old. Cultivation was impossible in the Ohio plantation, because the soil was full of old roots; in consequence a heavy growth of grass came in and the trees, when 8 years old, had reached a height of only 8 feet.

Cultivation serves several purposes. It conserves soil moisture, keeps out grass and weeds which would ordinarily compete with the trees for moisture, hastens the establishment and growth of the seedlings, lessens mortality among the planted stock, and shortens the rotation. This last point is of special importance in commercial plantations of the fence-post trees, such as hardy catalpa, European larch, black locust, Russian mulberry, and Osage orange, grown on a rotation of from 15 to 25 years on soil with an annual rental value of $4 to $6 per acre.

On poor sandy or rocky soil, where trees of commercial value can not be produced in less than 50 years, cultivation is generally not advisable. On such soils the growth of grass and weeds is usually insufficient to interfere very much with the growth of the trees, and the expense of cultivation, when figured at compound interest for 40 or 50 years, more than offsets the value of the resulting increased growth.

In cultivating a plantation there is always the danger of continuing the operation too late in the season. Forest trees, like fruit trees, are subject to damage by heavy, early frosts, and, if their wood is particularly succulent at the time when these occur, may be severely injured. Late cultivation is conducive to this condition of the wood, and no work of the kind should be continued beyond the first or middle of July. The grass or other vegetation coming in after this serves a good purpose in drying out the soil, thus checking the growth of the trees and hardening their wood. The danger of late cultivation can not be emphasized too strongly, since young plantations, even of the hardy black walnut, have been killed back to the ground by severe early frosts and winter freezing when cultivation was continued too late in the growing season.

It is not necessary that the entire cost of cultivation be borne by the plantation. Field crops of corn, potatoes, or beans may be grown between the rows for the first one or two years. These will not only yield a revenue to the owner, but their cultivatiion will benefit the young trees. Sometimes all of the cost of cultivating can be charged against the field crop, making a considerable difference in the final cost of the plantation.

The number of years in which cultivation is necessary and the amount of it each year will depend, of course, upon the rapidity of growth of the species planted and the spacing of the trees in the plantation. Some planters have found two cultivations a year for three years sufficient, except under unusually trying conditions. A three-year period should be ample, with possibly three or four cultivations during each of the first two seasons. The work may be done at first with a two-horse cultivator, and later, when the trees become larger, with a one-horse cultivator.

THINNING.

Every forest plantation reaches a condition after a few years when some of the standing trees should be cut out. The removal of undesirable trees is called a thinning. The principle is the same as that applied by truck gardeners to vegetable crops which are thinned out in order to get the best development of a portion of the crop rather than a meager development of the whole. The struggle for existence between the trees of the stand first induces rapid height growth and kills the lower branches, but, if allowed to continue, the more vigorous trees are prevented from making their best diameter growth by the presence of the less vigorous ones.

Where there is a poor market for the product from thinnings the operation will scarcely pay for itself; where the market is good, however, thinnings have been made at a net gain of from 10 cents to $2 per cord.[1] In the more widely spaced plantations thinnings will not be necessary until the product is of merchantable size. The future, moreover, promises a better market for small-sized material than exists at present, which will make thinnings profitable in stands in which now they would not be. In small plantations thinnings may be carried on by the owner at odd times at no cost other than his own labor. When poles are cut for some farm use a little care in their selection looking to the betterment of the stand will insure a crude form of thinning.

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[1] Bulletin No. 2, State Forester's Office, Massachusetts.

The presence of dead or dying trees in the stand, a very dense crown cover, or an apparent stagnation in the growth of the living trees indicates that a thinning is needed. The usual practice is to thin when the product is of sufficient size to pay for the operation and to repeat the process thereafter as often as the material has accumulated in sufficient quantity to again pay for the cost. Many plantations, however, need their first thinning before they reach this state. Silver maple, black locust, and other species have a decided tendency to grow toward openings in the crown canopy, and in their efforts to reach these the trunks become crooked. Under such conditions a thinning should be made whether the operation will pay for itself or not. The first thinning may be needed by the time the stand is 10 years old.

As a rule, trees of the least potential value should be the ones removed in a thinning. In the early life of a stand the trees range themselves into several crown classes—dominant, codominant, intermediate, suppressed, and dead. The dominant trees are the tallest ones, whose crowns receive almost complete sunlight; codominant trees are those of slightly less height, with relatively narrow crowns which are not fully exposed to sunlight; intermediate trees are considerably smaller than those of the first two classes, but still healthy, because their crowns continue to occupy open spaces in the canopy; suppressed trees are those hopelessly behind in height growth, and which will eventually be killed by the shade of the other trees. The trees which remain after a thinning should, as a rule, be those which are most vigorous, of the best form, and presumably of the highest final market value. This does not mean that no codominant or dominant trees should ever be cut, or that no intermediate and suppressed trees be allowed to remain. High-grade trees must sometimes be cut to obtain the proper opening of the crown canopy, and inferior trees may serve the useful purpose of shading the soil, thus tending to retard evaporation and prevent the growth of harmful vegetation on the forest floor. Except where needed for soil shading, however, suppressed and intermediate trees should generally be thinned in preference to the larger trees of the first two classes. When it can be done cheaply dead trees should be removed in order to rid the stand of material likely to increase the danger from fire.

The extent to which the crown of a stand may be opened depends largely upon the rate of growth of the species and their demand for light. In general, openings should not be so large that they will not close again within from three to five years by the growth of the remaining crowns. Rapid-growing trees, such as cottonwood or silver maple, should have their crowns opened to a much greater extent than stands of slower growing species, such as ash, oak, or walnut. Intolerant trees, such as cottonwood, European larch, black locust, or black walnut, require large openings in the crown cover. Cottonwood and European larch in particular die for no apparent cause except insufficient light, even when apparently receiving an abundance. For white pine and Norway spruce the openings need not be large.

There are no instances in this country where thinnings have been systematically carried on, and for this reason it is not possible to cite examples of their effect. The comparative size of trees grown in open-spaced and close-spaced stands, however, is something of an indication of the results to be expected from thinning, and a few examples of this sort are given in Table 2. Comparisons should be made, of course, only between stands or rows of nearly the same age.

TABLE 2.—*Size of trees in open and close spaced stands.*

European larch.				White pine.				Cottonwood.			
Nature of stand.	Age.	Spacing.	Average diameter breast high.	Nature of stand.	Age.	Spacing.	Average diameter breast high.	Nature of stand.	Age.	Spacing.	Average diameter breast high.
	Yrs.	*Feet.*	*Inches.*		*Yrs.*	*Feet.*	*Inches.*		*Yrs.*	*Feet.*	*Inches.*
Grove	28	8 x 8	7.6	Grove	35	6 x 7	8.8	Grove	12	5½ x 8	8.4
Do	28	10 x 12	9.2	Do	37	8 x 9	9.7	Do	13	4 x 5	3.9
Row	28	(1)	10.6	Do	39	4 x 4	8.1	Do	35	8½ x 8½	13.3
Grove	35	8 x 8	10.0	Do	43	16 x 16	12.3	Row	35	(3)	19.3
Do	35	7½ x 7½	11.2	Do	43	1 x 6½	7.5	Grove	36	5 x 10	13.4
Do	37	8 x 8	10.0	Row	53	(2)	14.1	Do	40	2 x 36	17.6
Do	35	3 x 7	7.4	Grove	53	6 x 7	11.1	Do	41	6 x 6	12.3
Do	39	3¾ x 3¾	7.0								
Do	40	4 x 4	8.3								

[1] 5 feet apart in row.
[2] Trees 6 feet apart.
[3] 2 to 4 feet apart in row.

PRUNING.

Pruning is the removal of living or dead branches from a tree. The purpose is to improve the tree's form; to increase growth in its leading shoot by eliminating some of the lateral shoots and to improve the quality of the lumber by getting rid of the source of knots.

Most trees in forest plantations, especially those closely spaced at the start, will prune themselves; the additional value gained by pruning them by hand is usually not sufficient to pay for the operation. The cost, therefore, would have to be reckoned as a fixed charge, to run at interest, against the final cost of the plantation. In small plantations, however, it may be possible for the owner himself to do the pruning at odd times, and thus avoid an additional charge. Side branches can not well be pruned to a greater height than a man can reach from the ground with an axe, and this amount of pruning will scarcely have much effect in increasing the stumpage value of the timber.

Another objection to pruning is the danger of overdoing it. If a tree is pruned too far up it may become top heavy and be broken off in a severe wind. Catalpa, ash, and black cherry are particularly susceptible to injury in this way. The stems of young black cherry and ash, when pruned far up, bend over by their own weight nearly at right angles. Sucker sprouts then shoot up from the bent stems, making a deformed tree. In a stand of black cherry 8 years old in Indiana, where the trees were pruned to a whip, 11 per cent had been broken off by the wind.

Pruning also reduces the amount of leaf surface, the food-making part of the tree, and hence reduces its rate of growth.

Especially valuable species and trees with very persistent branches should be trimmed at least of their dead branches and sometimes of their living ones. Of the species commonly planted, white pine, black walnut, hardy catalpa, and black locust sometimes need pruning.

The lower branches of white pine are large and persist for many years after dying. Sometimes, but not as a rule, it will be profitable to prune the best trees in the stand by simply knocking off the limbs with an axe after they are dead and have become brittle. Black walnut seldom needs pruning, though occasionally dead branches persist for a number of years which are likely to form loose knots in the lumber. Such branches should be removed. Hardy catalpa has very persistent branches, though the presence of knots in fence posts, the chief product of catalpa plantations, scarcely impairs their value. The dead branches are objectionable, however, because they become loose and allow the entrance of wood-rotting fungi. Since, therefore, these branches are a menace, they should be removed. Catalpa, moreover, does not form a terminal bud, but ordinarily develops three buds at each node. From those at the node nearest the tip of the last year's shoot three new shoots arise, any one of which may develop into a leader. In order to increase the development of one of these shoots and thus control the tree's form, one or both of the other two shoots on the node should be removed. An effective and cheap way of doing this is to pinch off these shoots just as they are developing from the buds. Black locust ordinarily prunes itself readily, but when widely spaced the main stem often forks into two or more main branches. In one young plantation of black locust in Illinois, spaced 8 by 11 feet, fully 43 per cent of the trees showed this fault. Such trees should if possible be pruned of all but one of their leaders.

The lower branches of Norway spruce are very persistent, but not very large; hence for ordinary purposes the tree requires no pruning. The ashes ordinarily prune themselves of their lower branches, but the leader from year to year seems to develop as commonly from one of the lateral buds as from the terminal one, resulting in a crooked bole. The ash plantations examined have grown too slowly to make pruning a profitable operation, but if especially straight stuff is desired it can be obtained either by very close spacing or by pruning. Ash will grow fairly straight if spaced closely, and pruning should accomplish the same result as close spacing. One method of pruning is to cut off each year the lateral shoots which threaten to compete with the leader; another is to pinch off the lateral buds formed near the tip on the terminal shoot.

The branches of European larch die early, but are very persistent. Pruning this tree does not pay, however, because the products of the plantation (chiefly posts and poles) are almost, if not fully, as valuable when somewhat knotty as when clear.

Cottonwood prunes itself exceptionally well, and soft maple, black cherry, and Scotch pine also lose their branches readily. The oaks, as a rule, are not good self-pruners, but they grow so slowly that pruning is not a profitable operation.

MIXTURES.

Comparatively few plantations of mixed species have been set out in the region under discussion, and in the few cases where this has been done the mixture has usually proved unsuccessful. This has been due, however, more to the planters' ignorance of the requirements of the species planted than to any essentail defect in the method itself. A mixture of two or more species is often desirable. Some trees, such as cottonwood and European larch, need to be spaced widely, while others, like black walnut and black locust, have such a scant foliage that they do not shade the ground completely enough to prevent the growth of a heavy sod of grass. In such cases a mixture will more completely utilize the area planted, thus increasing the yield, and at the same time will bring about better forest conditions in the plantation.

Mixtures are desirable for other reasons. Planting stock of such species as white pine and European larch is expensive, and a less valuable species mixed with the main crop, and removed later in thinnings, will keep down the first cost. If a species to be planted is susceptible to serious insect or fungous attack, as is white pine or black locust, the mixture of another species not susceptible will provide for a stand of trees on the area in case the pine or locust is killed. When such species as European larch, white pine, or black walnut are widely spaced, in order to promote the most rapid growth, it may be advisable to interspace the area with some more tolerant and slower-growing species.

A number of mixtures are given below which should prove successful on soils adapted to both species of the mixture, and which are likely to have one or more of the advantages cited. The principal species in each mixture is named first; and where they take equal rank the fact is indicated by an asterisk (*):

1. Cottonwood and silver maple.
2. Cottonwood and Norway spruce.
3. Cottonwood and white spruce.
4. Cottonwood and green ash.
5. * European larch and white pine.
6. * European larch and red oak.
7. European larch and white spruce.
8. * European larch and Norway spruce.
9. White pine and Scotch pine.
10. * White pine and Norway pine.
11. White pine and hard maple.
12. White pine and red oak.
13. Black walnut and white spruce.
14. Old open stands of black walnut underplanted with white pine.

Many of the old groves, particularly in Iowa, are of soft maple. These may be gradually replaced by underplanting with white spruce and removing the maple.

PROTECTION.

INSECTS.

The locust borer has completely destroyed many plantations of black locust; the white-pine weevil kills the leading shoot of white pine; the gipsy and brown-tail moths defoliate the hardwoods, particularly the oaks, and in some cases have attacked conifers; while the sawfly has defoliated and killed much of the native larch and has attacked also the European larch. Before setting out any trees the prospective planter should communicate with the Bureau of Entomology of the Department of Agriculture, or with the State experiment station, in order to find out whether insect enemies of the species he proposes to plant are prevalent in the neighborhood. At the first sign of insects in an established plantation the owner should likewise communicate with the Bureau of Entomology to ascertain the best methods of combating them.

FIELD MICE AND RABBITS.

Young trees are sometimes girdled by field mice and rabbits. Where these pests are numerous it is almost impossible to prevent them from eating the bark of trees during the winter when green food of other kinds is absent. If the grass around the tree is killed by cultivation there will be less danger from field mice, since these work largely under the grass covering. Poisoning is not always an efficient method of getting rid either of mice or rabbits; and poisoned food may kill some valuable domestic animal.

WIND, SNOW, AND FROST.

High winds often break or twist off the trees in a plantation. Such damage may be avoided to some extent by planting wind-firm species around the edge of the plantation, or by spacing the trees more closely on the windward sides.

Snow and frost may also cause considerable damage; the former weighs down and breaks off branches and leaders; the latter, when occurring late in spring or early in autumn, may kill the succulent wood. Damage from snow is less likely with hardwood trees than with conifers, because the bare branches of the former do not permit as much of it to accumulate. Frost damage may be partly avoided by planting hardy species or by utilizing sites on north, northeast, or northwest slopes, where growth begins comparatively late in spring and stops early in the fall. Low sites on which there is poor circulation of air should be avoided.

GRAZING ANIMALS.

Sheep, cattle, or horses should never be allowed in a young plantation. They browse upon leaves and tender shoots and trample the trees, which become crooked, branchy, and dwarfed. If pasturing is continued the trees will eventually be killed. Bulletin 200 of the Wooster (Ohio) Agricultural Experiment Station, sums up, for Ohio, the damage from this source:

> The acres of young forest which have been needlessly destroyed within the State foot up into the millions. Their value, had they been protected from live stock, would to-day amount to double the sum which has been realized from the pasture. This is demonstrable, for the investigations of the experiment station have shown that the value of young forest-tree growth exceeds the value of woodland pasture more than two to one. There is no such thing as profitable woodland pasture. The combination of grass and forest is incompatible. Cattle derive but little, if any, benefit from browsing or from the shaded innutritious grasses, but they do damage the trees. The losses from this practice are larger to-day than ever before because of the constantly increasing value of the trees which are destroyed.

In a plantation of green ash at Kanawha, Iowa, trees which had been protected from cattle were from 10 to 17 feet high, while others of the same age which had been browsed by cattle were for the most part only 4 feet high. In a 5-year-old plantation of black locust in Michigan, grazed by both sheep and cattle, ungrazed trees had reached an average height of from 8 to 14 feet, when those browsed by the stock were only from 2 to 3 feet high. In a 10-year-old plantation of black walnut in Indiana, grazed by cattle, 25 per cent of the living trees had been broken by stock, and averaged from 5 to 6 feet in height; the unbroken trees were from 19 to 25 feet high. The owner stated that the trees were pretty well tramped out at one time, which accounts for the fact that of the trees originally planted 78 per cent are now missing.

In older plantations the damage done by stock consists largely in packing of the soil. As a result of the stock running at large, the humus is destroyed and the roots of the trees exposed and perhaps wounded, while the soil becomes impervious to water. The stand, of course, suffers accordingly. Moreover, fungi may enter the trees through wounds around the base or in the roots.

Hogs root up the soil and expose the tree roots to the air, or even devour the roots themselves. In Iowa hogs completely destroyed one plantation of European larch in this way. Young trees are very likely to be rooted completely out of the ground.

If shade and protection for stock can be obtained in no other way, the animals can be admitted to one portion of a plantation and excluded entirely from the other portions, which should be devoted exclusively to the growing of timber.

FIRE.

Whenever there is any danger from fire, definite steps should be taken to guard against it. Most of the smaller plantations already established are located near the owner's residence, where they can be kept under observation, but in some of the larger plantations, where a close watch has not been kept, fires have done considerable damage. The owner of a large plantation should certainly make some provision to protect it, especially if it is near a railroad or is likely to be visited by picnic parties. Fire lines might be constructed, and a general watch should always be kept. Roads often make good fire lines, and when so used should be kept free from grass. Where no roads pass through the tract, fire lines from 6 to 8 feet wide may be plowed around the area, or else a strip of this width burned or otherwise kept cleared of all inflammable material. A fire line ceases to be a fire line wherever it becomes covered with litter or a heavy growth of grass.

DISEASES.

The diseases to which the different kinds of trees are subject and the methods of combating them can best be ascertained by consulting with the Office of Forest Pathology, Bureau of Plant Industry, Washington, D. C., or the State experiment station. Prospective planters are strongly advised to do this before purchasing their trees. Nursery stock, particularly that from abroad, is often diseased.

MISTAKES IN TREE PLANTING.

Forest plantations have too often been started by those with little knowledge of the requirements of the trees set out, and who were often influenced in their choice of species by advertisements of tree agents. It is little wonder, then, that mistakes have been made. Planting operations should not be undertaken until a thorough inquiry has convinced the owner as to which species is best adapted to his purpose and which will succeed on the planting site selected. Advice and aid can be obtained by prospective planters from their respective State foresters, a list of whom is given in the Appendix. The Forest Service of the United States Department of Agriculture also gives advice in regard to the best species to plant and methods of planting.

To enable planters to avoid errors made by other planters in the past, some of those observed in the course of the study are described:

(1) Planting European larch and silver maple in mixture killed the larch, which is the more valuable tree of the two.

(2) Planting black walnut under green ash killed the walnut, which must have full sunlight in order to succeed.

(3) Catalpa planted under black locust grew very slowly. Catalpa requires full sunlight for good growth.

(4) European larch planted under catalpa did not live. Larch requires full sunlight.

(5) Box elder planted in mixture with green ash at first grew more rapidly than the other species and shaded out much of it, though ash is the more valuable tree.

(6) Cottonwood planted on a gravel knoll did not live. The situation was too dry for it.

(7). The roots of cottonwood planted in a "blowout" in sandy soil were exposed by the shifting of the sand; the trees, when observed, were very scrubby and dying.

(8) Catalpa planted on a gravel knoll was only about 2 feet tall after 7 years. Such soil is not suited to catalpa.

(9) Catalpa trees planted in soil with a hardpan about 8 inches below the surface were only 3 or 4 feet high after 7 years of growth. Catalpa requires a deeper, well-drained soil.

(10) Ash planted in a "blowout" in pure sand, while still alive after 5 years, was not much larger than when set out. A pure sandy soil is not suited to ash.

(11) Black walnut and green ash planted in low wet ground made a scrubby growth. The soil was not well enough drained for either of them.

(12) Osage orange planted in pure sand failed to survive. Osage orange requires a fairly good soil.

(13) Three-year-old ash stock, which cost a good deal in the first place, and had to be set in by the most expensive methods, grew so poorly that it was necessary to cut the trees back to the ground after a couple of years. The stock was too large when planted to succeed well.

YIELDS AND RETURNS.

The yields in products and the money returns to be expected from plantations are given in the tables for individual species (pp. 24 to 32).

Existing plantations do not, as a rule, afford a good basis for estimating possible yields and returns from plantations started now, for species have often been planted on inhospitable sites, spacing has been too wide or too close, almost no attention has been given to proper thinnings, and live stock has been allowed to run among the trees. Moreover, the cost of planting stock has often been excessive; $20 a thousand for European larch and $20 to $25 a thousand for hardy catalpa is unduly high. It has been practically impossible to obtain wholly reliable cost data for a given plantation or the exact amount of products secured from it prior to the time when it was examined. In many cases the original planters have died or moved away, or have kept no accurate record of costs or returns.

In reckoning the cost of an income from plantations, interest has been calculated at 3 per cent, compounded annually. The land values and tax rate assumed are undoubtedly lower than those now in effect, but it should be remembered that neither averaged as high during the life of the plantation as the present figure. In estimating future returns from plantations started to-day, the land values assumed should be as high as those at present in effect, and even somewhat higher if the general trend in land values of the region is upward.

Even at the low interest rate of 3 per cent growing trees on land worth $100 to $150 an acre for the sole purpose of obtaining lumber and other products will not, at the present stumpage prices, prove a profitable undertaking. But if the plantation serves also as a protection against wind such planting should pay very well. It has been found that due to the protection afforded by the most efficient grove windbreaks the yield in farm crops is increased to the extent of that grown on a strip three times as wide as the height of the trees.[1] The protection afforded by his grove of ash and maple has been estimated by one farmer in Iowa to save him $300 per year in feed for his stock.

In view of advancing stumpage prices, it seems safe to estimate the yields from future plantations as being equal at least to the highest yields from plantations made in the past on similar sites. Timber products, moreover, will almost certainly advance in value, though it is open to question whether this advance will be sufficient to offset the rapidly increasing value of the land.

INDIVIDUAL SPECIES.

COMMON COTTONWOOD (Populus deltoides Marsh.).

The common cottonwood is the most rapid growing of the trees commonly planted. It is not exacting in regard to soil, but requires an abundance of moisture. It is very hardy and is especially adapted for planting on poor, sandy river-bottom sites where the water table is within from 4 to 6 feet of the surface. When 30 or 40 years old the trees begin to die in the tops and the stand to deteriorate. For its best development cottonwood requires an abundance of sunlight, and, if planted in groves, a wide spacing of 12 by 12 to 12 by 15 feet is needed. Closer spacing not only adds to the initial expense but results in the death of many trees from crowding before they are large enough to be of much value. When planted in groves, however, cottonwood should be underplanted with some such species as silver maple, in order fully to utilize the ground. This would insure better forest conditions than are generally found in open groves of pure cottonwood, and would promote the production of clear timber of a fairly high value. The main product derived from cottonwood is lumber, and from maple, cordwood.

A stumpage value for cottonwood of $8 per thousand board feet is considered low. In Iowa it brings from $10 to $12. For inside dimension timbers cottonwood is as good as higher priced material. The timber has been used for corncribs and barns. Heavy cottonwood planks, because of their toughness when seasoned, are especially desirable for the sides of horses' stalls.

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[1] Forest Service Bulletin 86, "Windbreaks."

Cottonwood cordwood is difficult to split after it becomes dry, but considerable quantities, in addition to lumber, are produced in groves or in rows. A value of $2.50 per cord on the stump is considered a fair average for the tree throughout the region in which it has been planted most extensively.

Cottonwood is easily propagated from cuttings. It has done well in Iowa, and probably would thrive throughout the whole eastern region, even to the New England States.

Table 3 gives the yield and value of cottonwood in Iowa. In this table and in the tables for the other species the total costs to date are determined by means of the formula, $\text{Cost} = (S+E+C)\ 1.0p^n - (S+E)$, where S = average value of land per acre, E = capitalized value of taxes $= \frac{\text{Annual taxes}}{\text{rate of interest}}$, C = cost of initial operations (preparation of soil, cost of stock, planting, and cultivation), and $1.0p^n$ = amount of $1 compounded annually at 3 per cent for a period equal to the age of the plantation. Total profit or loss per acre equals the amount by which the present value of products per acre exceeds or falls below the total amount of costs to date when computed at 3 per cent compound interest. Positive amounts are an excess profit above 3 per cent; negative amounts indicate the sums by which the profit fails to equal 3 per cent. Annual profit or loss per acre equals the total profit or loss per acre divided by the amount of $1 per annum at 3 per cent compound interest for a period equal to age of plantation.

TABLE 3.—*Yield and value of cottonwood (Populus deltoides) in Iowa.*

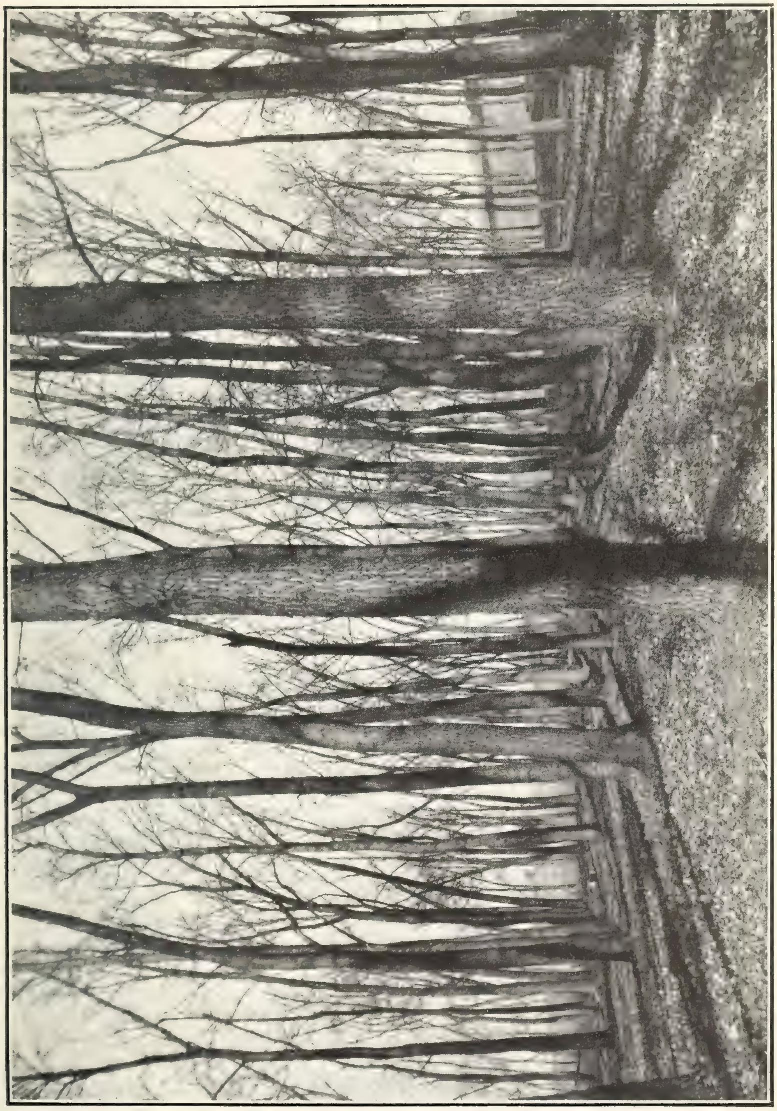
Age.	Soil.	Original spacing.	Present number of trees per acre.	Average diameter breast high.	Average height.	Yield per acre.		Average value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
						Timber.	Cordwood [1] (90 solid cu. ft.=1 cord=128 stacked cu. ft.).				Total.	Annual.
Yrs.		*Ft.*		*Ins.*	*Ft.*	*Bd. ft.*	*Cords.*					
12	Sandy black loam...	5½ x 8	372	8.4	54	3,900	23.79	$70.00	$39.90	$90.68	+$50.78	+$3.58
17	Black loam..........	5 x 8	291	9.2	66	10,350	16.37	70.00	63.24	123.72	+ 60.48	+ 2.78
28	.....do..............	5 x 6	204	11.4	56	12,320	17.38	65.00	100.32	199.33	+ 99.01	+ 2.30
29	.....do..............	2½ x 3	370	10.0	58	10,860	29.17	60.00	102.09	159.80	+ 57.71	+ 1.27
30	.....do..............	6½ x 7½	66	13.9	68	6,400	7.19	60.00	113.00	69.18	− 43.82	− .92
34	.....do..............	6 x 7½	126	14.5	87	23,850	12.20	50.00	103.70	221.30	+117.60	+ 2.04
34	Clay loam............	7 x 7	[2] 45 [3] 273	14.0	85	10,850	59.07	20.00	55.49	234.48	+178.99	+ 4.06
35	Loamy sand..........	8½ x 8½	137	13.3	77	24,500	9.34	40.00	87.77	456.85	+369.08	+ 6.10
35	Black loam..........	8 x 8	160	12.1	72	10,850	17.69	50.00	119.92	131.03	+ 11.11	+ .18
36	.....do..............	5 x 10	125	13.4	74	15,820	6.35	60.00	144.25	142.43	− 1.82	− .03
40	Quite sandy loam...	2 x 36	233	17.6	100	49,926	55.47	40.00	116.88	538.07	+421.19	+ 5.58
41	Black sandy loam...	6 x 6	193	12.3	93	14,700	7.74	30.00	92.50	136.95	+ 44.45	+ .57
43	Black loam..........	8 x 8	74	15.9	71	12,600	5.38	40.00	135.67	115.25	− 20.42	− .25
50	Black sandy loam...	8 x 8	89	13.9	65	15,500	......	30.00	136.73	124.25	− 12.48	− .11
[4] 35	Black loam..........	....	137	19.3	82	32,900	29.41	50.00	106.33	336.50	+230.17	+ 3.81
[4] 40	.....do..............	....	83	17.1	71	16,000	3.83	40.00	107.54	137.60	+ 30.06	+ .40

[1] In addition to the board feet shown in preceding column.

[2] Cottonwood.

[3] Maple.

[4] Single rows reckoned as 50 feet wide by 871 feet long=1 acre.



COTTONWOOD PLANTATION, IOWA. TREES MATURE AND LARGE ENOUGH FOR SAWING INTO DIMENSION TIMBERS.

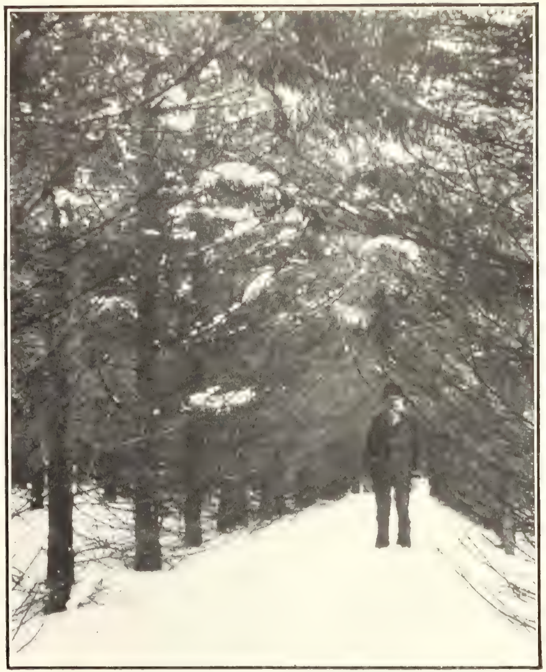


FIG. 1.—NORWAY SPRUCE PLANTATION, IOWA. DENSE BRANCHING MAKES IT DESIRABLE FOR WINDBREAK PLANTING.

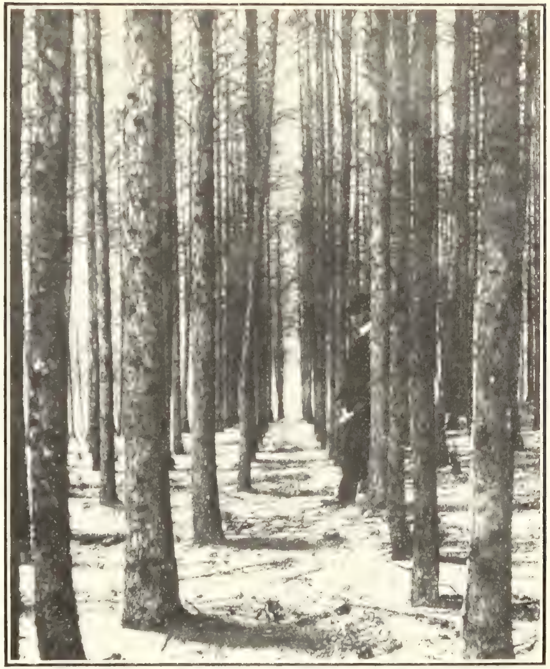


FIG. 2.—EUROPEAN LARCH PLANTATION, ILLINOIS, 27 YEARS OLD.

SILVER MAPLE (Acer saccharinum Linn.).

Silver maple is a rapid-growing tree, probably ranking next to cottonwood in this respect among the species discussed. It is also very hardy and comparatively free from serious insect or fungous attack. The tree, which reaches maturity in from 35 to 40 years, forms a rather crooked, twisted bole, and so yields very little lumber. Its chief value is for cordwood, or to insure a windbreak in a short time. Silver maple is occasionally used for posts for temporary fences, but is not durable in contact with the soil, and unless treated with a preservative, will not last more than two or three years.

Since silver maple is easily and cheaply propagated, it is a good tree to plant for the production of cordwood in the Middle Western States, and probably also in any part of the Northeast, provided the plantation is made on well-drained soils which are not subject to excessive drying out. A spacing of 6 by 8 feet is close enough.

In Table 4 $2.50 per cord has been assumed as the average stumpage value for the species.

Table 4.—*Yield and value of silver maple* (*Acer saccharinum*).

Age.	Location.	Soil.	Original spacing.	Present number of trees per acre.	Average diameter breast high.	Average height.	Yield per acre, cordwood (90 solid cu. ft. = 1 cord = 128 stacked cu. ft.).	Average value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
											Total.	Annual.
Yrs.			*Ft.*		*Ins.*	*Ft.*	*Cords.*					
9	Illinois..	Black loam.........	5 x 8	1,018	4.0	36	16.2	$125.00	$42.60	$40.50	− $2.10	−$0.20
12	Iowa....	Black sandy loam...	4 x 5	1,060	4.1	41	19.8	70.00	54.92	49.50	− 5.42	− .38
18	...do....	Black loam.........	3½x 4½	979	4.4	43	(?)	60.00	50.73	(?)	....	(?)
20	...do....	.....do..............	5 x 9	376	6.2	46	20.1	60.00	58.93	50.25	− 8.68	− .32
20	...do....	.....do..............	4 x 4	530	6.1	46	29.5	60.00	70.56	72.75	+ 2.19	+ .08
26	...do....	Quite sandy loam...	3½x 7	323	7.1	51	34.7	60.00	96.54	141.39	+ 44.85	+ 1.16
[1] 27	...do....	Black loam.........	6 x 8½	267	8.3	58	31.1	50.00	76.65	422.75	+346.10	+ 8.50
34	...do....	.....do..............	8 x 8	328	6.8	53	19.0	40.00	90.14	47.50	− 42.64	− .74
34	...do....	.....do..............	3 x 5	294	8.9	60	46.9	50.00	110.53	117.25	+ 6.72	+ .13
35	...do....	Clay loam...........	8 x 14	166	10.8	55	36.7	50.00	112.90	91.75	− 21.15	− .35
35	...do....	Black loam.........	4 x 7	274	8.1	74	38.0	40.00	90.58	95.00	+ 4.42	+ .19
35	...do....	.....do..............	6 x 8	177	10.4	52	32.8	50.00	118.92	82.00	− 36.92	− .61
35	...do....	.....do..............	7½x 7½	240	11.8	71	91.8	50.00	118.92	229.50	+110.58	+ 1.83
40	...do....	Black sandy loam...	8 x 8	298	8.5	66	40.4	50.00	144.68	101.00	− 43.68	− .58

EUROPEAN LARCH (Larix europaea deC.).

European larch has been planted quite extensively in Illinois and Iowa, and to some extent in Rhode Island, Connecticut, and Massachusetts. Results, however, do not bear out the claims made for it (see Table 5). This is in part because plantations in this country have not been made in situations similar to the native habitat of the species which is in the higher, cooler altitudes; the trees have not always been properly spaced, and the cost of planting stock has often been excessive (in one case $51 per thousand and in several others $20). Probably the most important reason for the poor returns, however, has been the lack of market for European larch telephone or telegraph poles, claimed to be the most valuable form of product. For this reason the owners have been unable to realize any profit from their plantations. In one instance in Iowa the owner secured from a local farmer's telephone company $1 each for poles 6 inches in diameter at the butt and 20 feet long, and $1.50 for slightly larger ones. As a rule, however, there is no demand for the poles, and lumber dealers do not handle them. They are considered as no more durable than white cedar poles, are much heavier than the latter, and the wood is so hard that it is difficult for a lineman to force his climbing irons into it. The values assumed for European larch poles are much less than those ordinarily received for similar-sized poles of other species: 15-foot poles, 20 cents; 20-foot, 30 cents; 25-foot, 50 cents; 30-foot, 75 cents; 35-foot, $1.25; 40-foot, $2; 45-foot, $3; and 50-foot, $4.50. First-class posts 4 to 6 inches in diameter at the small end and 7 feet long have been valued at 10 cents each, and cordwood at $1 per cord of 90 solid cubic feet.

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[1] The complete record kept of the amount of cordwood cut each year accounts for the large value of the products for this plantation.

European larch is exceedingly intolerant; closely spaced stands rapidly thin themselves, and thus do not fully utilized the ground. It seems advisable, therefore, to use a wide spacing of 10 by 10 or 12 by 12 feet, and fill in with some tolerant, slightly more slowly growing species, such as white pine, white spruce, or red oak. This wider spacing is especially desirable, since larch stock is expensive and the initial cost may be considerably reduced by filling in with a cheaper species. Larch requires a fresh, well-drained, moderately heavy soil. It does not do well in light, very sandy soils, or in very poorly drained, heavier ones,

It is not advisable to plant European larch in the New England States, because old plantations are now beginning to be attacked by the sawfly. In the Middle West it is questionable whether European larch would be as profitable if planted on the good soils (on which the present plantations stand) as some other species. It does not grow as rapidly as certain hardwoods which furnish fully as good post material, and it lacks their capacity to send up sprouts. Nothing excells it, however, in producing straight timber, and a few larch trees trees should be planted on every farm in the Middle West, in order to produce sticks for hay poles, braces, beams, scantlings, or other general utility purposes. Larch starts growth very early in the spring, and it is difficult to get stock for planting at that time which has not already started growth in the nursery.

TABLE 5.—*Yield and value of European larch (Larix europaea).*

Age.	Location.	Soil.	Original spacing.	Present number of trees per acre.	Average diameter breast high.	Average height.	Yield per acre.			Average value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
							Poles (all sizes).	Posts.	Cordwood[1] (90 solid cu. ft.=1 cord = 128 stacked cu. ft).				Total.	Annual.
Yrs.			*Ft.*		*Ins.*	*Ft.*	*No.*	*No.*	*Cords.*					
18	Iowa..	Sandy loam....	4 x 4	923	4.9	27	....	336	13.73	$65.00	$97.58	$47.33	−$50.25	−$2.15
27	...do...	Black loam.....	4 x 4	506	7.2	46	296	299	11.74	60.00	143.35	146.04	+ 2.69	+ .06
28	...do...	.....do..........	3½ x 6	1,107	3.7	40	110	....	15.56	30.00	104.83	43.46	− 61.37	− 1.43
28	Conn..	Loam...........	4 x 4	1,120	4.3	35	....	110	19.69	35.00	206.31	30.79	−175.52	− 4.09
28	Iowa..	Black loam.....	10 x 12	189	9.2	43	180	132	1.89	65.00	117.15	65.79	− 51.36	− 1.20
28	...do...	.....do..........	8 x 8	487	7.6	47	363	92	10.41	65.00	132.27	164.31	+ 32.04	+ .75
31	...do...	Clay loam......	4 x 5	526	7.6	57	351	429	10.48	60.00	147.12	226.03	+ 78.91	+ 1.58
33	Conn..	Loam...........	4 x 6	380	6.4	70	330	240	9.35	14.00	172.05	289.85	+117.80	+ 2.14
33	Mass..	.....do..........	(?)	212	6.5	53	124	32	4.94	15.00	171.45	56.34	−115.11	− 2.09
35	...do...	White sand....	4 x 4	527	6.6	43	219	140	12.48	15.00	49.23	111.88	+ 62.65	+ 1.03
35	...do...	.....do..........	4 x 4	1,324	4.5	29	27	216	20.97	15.00	49.23	47.97	− 1.26	− .02
35	Iowa..	Black loam.....	8 x 8	221	10.0	57	214	170	3.97	50.00	131.57	172.42	+ 40.85	+ .67
35	...do...	.....do..........	7½ x 7½	192	11.2	57	191	155	3.00	50.00	133.68	205.05	+ 71.37	+ 1.18
35	...do...	.....do..........	4 x 6	498	7.4	44	325	305	10.33	60.00	163.02	157.58	− 5.44	− .09
35	...do...	Clay loam......	3 x 7	475	7.4	68	466	308	10.72	25.00	112.20	275.42	+163.22	+ 4.35
37	...do...	Black loam.....	4 x 4	330	8.9	57	308	330	6.26	50.00	194.41	252.46	+ 58.05	+ .88
39	Ill.....	.....do..........	(?)	571	7.7	54	391	462	12.10	80.00	272.59	214.50	− 58.09	− .80
39	Iowa..	Black sandy loam.	3½ x 3½	522	7.0	53	378	269	12.91	60.00	235.15	150.51	− 84.64	− 1.17
40	...do...	Black loam.....	4 x 4	398	8.3	52	342	193	7.44	30.00	160.78	212.04	+ 51.26	+ .68
41	...do...	.....do..........	4 x 4	299	9.4	45	274	429	10.48	30.00	147.12	226.03	+ 78.91	+ 1.58
41	...do...	Black sandy loam.	8 x 8	292	8.3	64	285	435	6.51	40.00	137.28	223.01	+ 85.73	+ 1.09
50	Mass..	White sand....	6 x 6	316	7.3	49	264	71	6.71	10.00	84.36	103.61	+ 19.25	+ .17
60	...do...	Clay loam......	6 x 6	155	9.7	62	153	162	2.96	10.00	117.58	110.06	− 7.52	− .05
[2] 28	Iowa..	Black loam.....	5	1,000	10.6	50	608	340	5.81	65.00	115.32	189.92	+ 74.60	+ 1.74

[1] In addition to the poles and posts shown in preceding columns.
[2] Single row reckoned as 25 feet wide by 1,742 feet long = 1 acre.

SCOTCH PINE (Pinus sylvestris Linn.).

Scotch pine will grow in all sections of the eastern United States, and is well adapted for sandy soils too poor for agriculture or even for the growth of white pine. The tree seems to do equally well on the poor, sandy, Norway pine lands of Michigan and on old worn-out lands of New England. For the first 15 or 20 years Scotch pine makes very rapid height growth, often from 20 to 30 inches a year.

Because of its hardiness and freedom from disease, it is to be regretted that the Scotch pine already planted consists largely of a variety from central Germany, the trees of which, when about 20 years old, become crooked, irregular, ragged, and of very poor timber form, yielding only one or two logs per tree. In Europe, on the other hand, trees grown from seed collected in the Scotch pine forests of the Baltic provinces of Russia, ordinarily called the Riga variety, have straight, cylindrical, well-developed trunks, and yield wood of a higher quality than the Scotch pine of central Germany. Unless, therefore, the Riga variety can be secured, the planting of Scotch pine is not recommended.

The tree is decidedly intolerant, and a rather wide spacing, 6 by 8 or 8 by 8 feet, is advisable, or it may be planted in mixture with white pine on soils adapted to both species. In the latter case a spacing of 6 by 6 feet, with the two species alternating, will probably give the best results.

Stumpage values for Scotch pine in the Middle Western States are placed at $8 per thousand board feet for lumber and $2 per cord for cordwood.

TABLE 6.—*Yield and value of Scotch pine (Pinus sylvestris).*

Age.	Location.	Soil.	Original spacing.	Present number of trees per acre.	Average diameter breast high.	Average height.	Yield per acre.		Av. value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
							Timber.	Cordwood [1] (90 solid cu. ft.=1 cord=128 stacked cu. ft.).				Total.	Annual.
Yrs.			*Ft.*		*Ins.*	*Ft.*	*Bd.ft.*	*Cords.*					
37	Iowa..	Black loam.	4 x 4	884	6.4	49	2,478	60.00	$40.00	$127.67	$139.82	+$12.15	+$0.18
39	...do...	...do........	4 x 8	497	8.4	44	6,971	31.11	50.00	179.58	117.99	− 61.59	− .85
40	...do...	...do........	8 x11	362	9.6	44	7,943	24.43	50.00	183.80	112.40	− 71.40	− .95
41	Ill.....	...do........	7 x16½	375	8.5	41	5,781	26.74	80.00	233.72	99.73	−133.99	− 1.70
40–50	Mass..	Poor sand...	6 x 6	521	6.8	29	......	......	10.00	....	....	....	......

[1] In addition to the board feet shown in preceding column.

WHITE PINE (Pinus strobus Linn.).

White pine seems well suited to the climate of the whole eastern portion of the country from New England to Iowa. It is not particularly exacting as to soil, but requires good drainage. It flourishes on the worn-out pasture lands of New England, on the almost pure sands of Cape Cod, and on the good agricultural soils of the Middle West. It will also undoubtedly thrive on some of the poor, sandy farm lands of the Indiana and Ohio region.

White pine is fairly tolerant, and in order to secure a clear bole very close spacing, 4 by 4 feet or 4 by 6 feet, is necessary. In practice, however, a spacing of 6 by 8 feet to 8 by 8 feet is usually close enough. In a stand 50 years old, spaced 6 by 8 feet, the branches die to a height of 40 to 50 feet, and though they persist, the knots are usually sound and the timber of fairly good quality. In a three-row windbreak in eastern Iowa, 52 years old and spaced 6 by 7 feet, the owner cuts timber which, although somewhat knotty, sells as lumber for from $36 to $38 per thousand feet board measure. White pine is recommended for windbreak planting in the Middle West, since it is an excellent tree for the purpose and produces a large amount of timber of good quality.

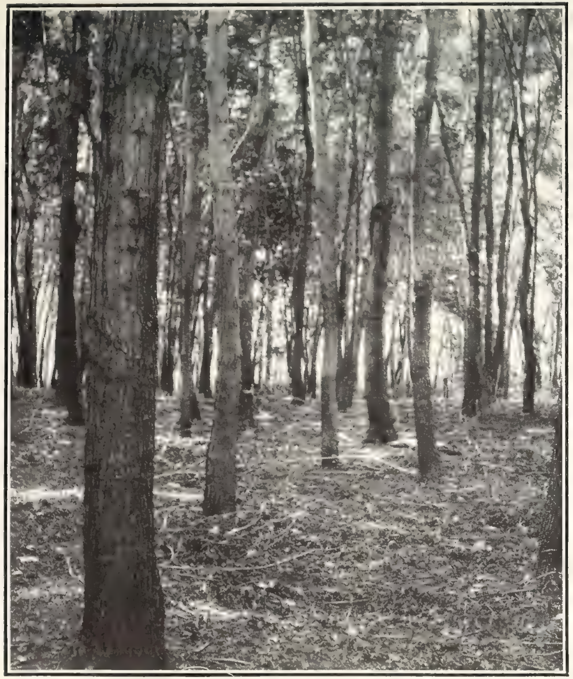


Fig. 1.—Silver Maple Grove, Iowa, Showing Good Forest Floor Conditions and Rather Typical Crooked Growth of the Species in this Region.

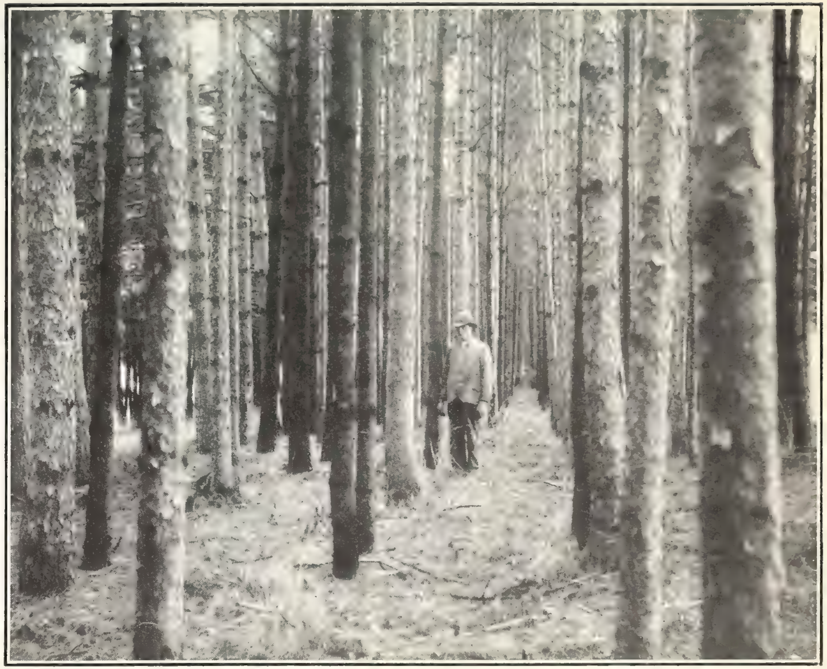


Fig. 2.—Norway and White Pine in Mixture, Northeastern Iowa, 43 Years Old. Original Spacing 1 by 6 Feet.

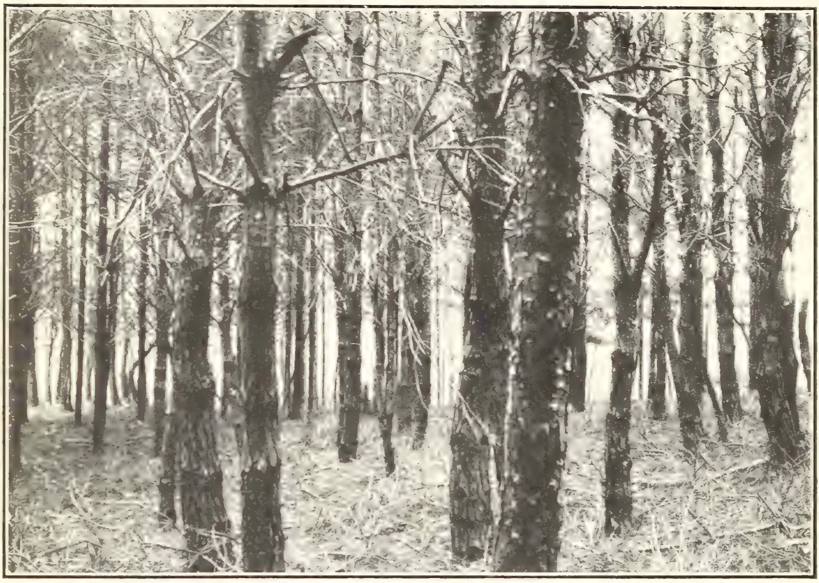


FIG. 1.—SCOTCH PINE PLANTATION, CAPE COD, MASS., 35 YEARS OLD, ON VERY SANDY SOIL.

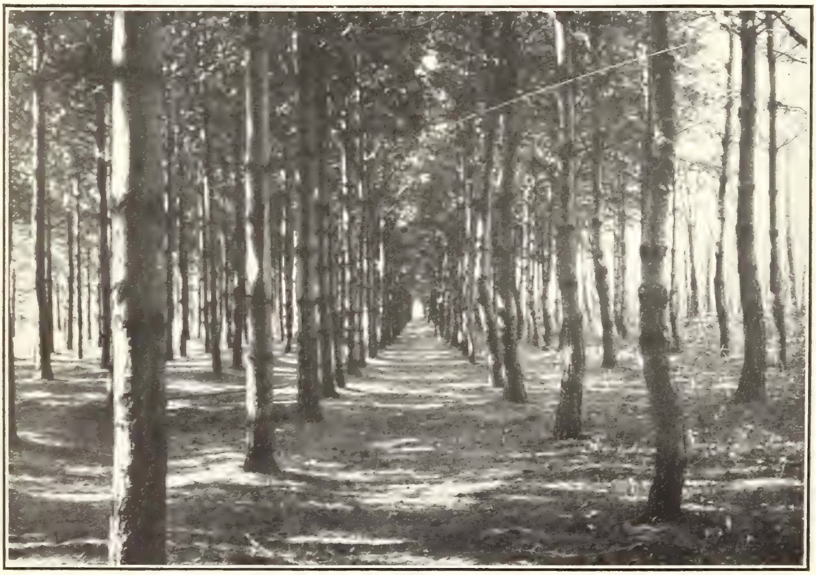


FIG. 2.—TWENTY-THREE-YEAR-OLD PLANTATION, IOWA. SCOTCH PINE ON RIGHT, WHITE PINE ON LEFT. SHOWS CHARACTERISTIC APPEARANCE OF SCOTCH PINE IN THIS REGION AFTER AGE OF 20 YEARS.

Where white pine grows well there is no object in planting it in mixture with other species. In certain regions, however, particularly in New England, the tree is subject to attack by the white pine weevil (*Pissodes strobi* Peck), which kills the top of the leading shoot through a year or two of its growth. A new leader is ordinarily formed by one of the side shoots, which in turn is subject to attack. The result is a crooked, unsightly tree, whose value for timber is considerably impaired, especially in stands grown on a short rotation, when there is not sufficient time for the crooks to be covered through growth of the bole. Wherever the weevil has appeared it would be better to plant Norway pine with the white pine than to plant the latter species alone. Young Norway pine grows as rapidly in height as the white, and though its lumber is less valuable, it is less subject to attack by the weevil.

In Table 7 the white pine plantations listed are all in the Middle West. Similar figures for New England plantations appear in other publications of the Forest Service and of various New England States. For the Middle West white pine stumpage has been given a value of $10 per thousand feet for stands with an average diameter under 11 inches, and of $12 for stands 11 inches and over, both of which are very conservative. White pine is usually cut by small portable sawmills, and the felling and sawing together do not cost more than $12 per thousand feet board measure for lumber which brings from $36 to $38 per thousand.

TABLE 7.—*Yield and value of white pine* (*Pinus strobus*).

Age.	Location.	Soil.	Original spacing.	Present number of trees per acre.	Average diameter breast high.	Average height.	Yield per acre in timber.	Average value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
											Total.	Annual.
Yrs.			*Ft.*		*Ins.*	*Ft.*	*Bd. ft.*					
21	Iowa..	Black loam...........	11 x 14	215	8. 7	39	4, 760	$80. 00	$68. 31	$57. 60	−$10. 71	−$0. 72
23	...do ..	Clay loam..............	6 x 8	409	7. 3	39	4, 273	30. 00	48. 23	62. 73	− 14.50	− .17
35	...do ..	.....do................	6 x 7	391	8. 8	52	12, 031	25. 00	75. 67	120. 31	+ 44. 64	+ .74
37	...do ..	Black loam...........	8 x 9	549	9. 7	50	22, 513	40. 00	113. 96	225. 13	+111. 17	+ 1. 68
39	Ill.....	.....do................	(?)	371	8. 5	39	7, 380	80. 00	272. 59	73. 90	−198. 69	− 2. 75
39	Iowa..	Black sandy loam.....	4 x 4	788	8. 1	47	16, 136	40. 00	173. 73	201. 36	+ 27. 63	+ .38
[1] 41	...do..	Black loam...........	8 x 8	408	[2] 9. 4 [3] 10. 1	62 64	16, 748	30. 00	113. 00	260. 81	+147. 81	+ 1. 89
42	...do..	.....do................	1 x 6½	850	7. 5	53	15, 206	30. 00	107. 73	152. 06	+ 44. 33	+ .54
42	...do..	.....do................	16 x 16	158	12. 3	60	13, 175	30. 00	98. 21	158. 10	+ 59. 89	+ .73
52	...do..	.....do................	6 x 7	374	11. 1	59	26, 400	20. 00	137. 59	316. 80	+179. 21	+ 1. 47
[4] 48	...do..	.....do................	4	560	16. 0	60	86, 640	30. 00	127. 93	346. 56	+218. 63	+ 2. 09
[4] 52	...do..	.....do................	6	435	14. 1	59	50, 500	30. 00	108. 58	202. 00	+ 93. 42	+ .77

[1] Mixture of white pine and European larch. Larch products are included in the returns.
[2] Pine.
[3] Larch.
[4] Single rows reckoned as 25 feet wide by 1,742 feet long=1 acre.

NORWAY SPRUCE (Picea excelsa Link).

Norway spruce has not been planted very extensively anywhere in the eastern United States. Because of its compact crown, especially when young, and the tenacity of its lower branches, this species has found favor in the Middle West for windbreaks of one to three or four rows. It will probably increase in favor. The tree prefers a fresh, well-drained, loamy soil, but in New England has succeeded fairly well on a sandy one. A young plantation on very sandy land in central Michigan, however, while still alive, is making a height growth of only 2 or 3 inches a year, while Scotch pine on a similar site is growing at the rate of from 6 inches to 2 feet a year.

Norway spruce is decidedly tolerant, and to obtain timber of the best form it should be spaced as closely as 5 by 5 feet to 6 by 6 feet. For windbreak purposes, however, the spacing should be not less than 12 by 12 feet, in order to insure that the lower branches will remain alive and bear foliage. Timber from such trees, while not clear, is of fair quality, and has been used in the Middle West for farm buildings. Norway spruce is also suitable for underplanting old groves of trees with naturally open crown covers, such as black walnut or cottonwood, and stands becoming open through deterioration. The species grows nearly as fast as white pine, and on loamy soils would probably be a good tree to plant in mixture with the latter. It appears to be hardy as far west as central Iowa, but west of that it is ragged and scrubby when mature, at the age of about 40 years. Some nurserymen attribute this to the severe winds in that region; though the extremely high summer temperatures and low humidities may have something to do with it, since spruce is naturally a tree of relatively cool regions with high humidities. Where exposed to severe winds, as on the New England coast, the tree is likely to be broken off or its top bent.

For the Middle West, Norway spruce has been assigned a stumpage value of $9 for lumber and $2.50 for cordwood, and for the northeast region $5 for lumber and $1 for cordwood.

BLACK WALNUT (Juglans nigra Linn.).

Black walnut does well throughout the central hardwood region, and as far west as the Missouri River. It is a hardy tree, and though seldom planted in the Eastern States there is no reason why it should not succeed there. For its best development, however, the tree requires deep clay or sandy loam soils, which, of course, are also excellent for agriculture. For this reason alone it is not likely to be planted to any great extent.

Black walnut is easily propagated by planting the nuts in the fall on the permanent site. The tree is decidedly intolerant, and sheds its lower branches readily even with a relatively wide spacing. One of 6 by 8 feet or 8 by 8 feet is close enough. The older trees, however, have open crowns, and should be underplanted as soon as they cease to cast shade enough to prevent a growth of grass on the forest floor. For such underplanting, white pine, white or Norway spruce, or red oak, should prove satisfactory.

Black walnut does not grow very rapidly, and takes from 60 to 100 years to produce the best timber. In general, it is not a particularly good tree for private owners to plant.

The only value given to black walnut in plantations has been $4 per cord on the stump. (See Table 8.) This is undoubtedly too high for cordwood alone, but since much of the material can be used for braces or small poles, the valuation is probably a fair one.

TABLE 8.—*Yield and value of black walnut* (*Juglans nigra*).

Age.	Location.	Soil.	Original spacing.	Present number of trees per acre.	Average diameter, breast high.	Average height.	Yield per acre, cordwood (90 solid cu. ft. = 1 cord = 128 stacked cu. ft.).	Average value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
											Total.	Annual.
Yrs.			*Feet.*		*Ins.*	*Ft.*	*Cords.*					
12	Indiana.	Black sandy loam..	4½ x 6	512	3.8	27	7.5	$70.00	$39.97	$30.00	−$9.97	−$0.70
25	Iowa....	Black loam..........	8 x 8	359	6.3	42	14.8	60.00	79.77	59.20	−20.57	− .56
28	...do.....	......do...............	8 x 8	548	5.5	42	17.9	60.00	91.67	71.60	−20.07	− .47
28	...do.....	......do...............	1½ x 7	708	4.1	26	8.6	60.00	97.16	34.40	−62.76	− 1.46
28	...do.....	Black sandy loam..	4 x 4	342	7.0	41	20.0	60.00	96.02	80.00	−16.02	− .37
31	...do.....	Black loam..........	4 x 5	492	7.0	51	34.6	50.00	93.12	138.40	+45.28	+ .91
32	...do.....	......do...............	5 x 13	239	8.3	54	24.2	50.00	95.99	96.80	+ .81	+ .02
35	...do.....	Black sandy loam..	8 x 9	149	8.7	46	12.4	50.00	109.80	49.60	−60.20	− 1.00
37	...do.....	Black loam..........	8 x 8	136	7.7	44	9.1	60.00	135.81	36.40	−99.39	− 1.50
38	Illinois..	......do...............	8 x 8	303	8.6	55	33.8	80.00	205.95	135.20	−70.75	− 1.02
40	Iowa....	......do...............	4 x 4	321	8.3	52	31.8	40.00	114.92	127.20	+12.28	+ .16
42	...do.....	......do...............	7 x 12	138	12.3	66	39.6	40.00	120.62	158.49	+37.87	+ .46

ASH (GREEN AND WHITE) (Fraxinus lancecolata Borkh. and Fraxinus americana Linn.).

Green ash has been planted to some extent in Iowa and Illinois, while east of these States white ash has been given preference. In the Prairie States green ash withstands more trying conditions, especially drought, than white ash, but with suitable soil conditions either species should succeed in any part of the eastern region. Both species prefer good, fresh, well-drained clay or sandy loam soil, but both also give promise of growing well on the poor, worn-out clay, or rocky clay farm soils of the central hardwood region. This fact may make them valuable trees for planting on those lands, since the lumber of mature trees has a high value and may be closely utilized for handle material. Ash, moreover, may be easily and cheaply propagated simply by sowing the seed on the permanent planting site. Ash is intolerant and sheds its lower branches well, and considering this reason alone it would seem that a rather wide spacing should be used. But on account of its habit, discussed on page 18, of commonly forming its leader from one of the side shoots, it seems best to use a closer spacing, 4 by 4 feet to 4 by 6 feet, in order, if possible, to correct the habit. The stand should then be thinned as soon as needed.

Green ash has come up naturally under cottonwood, and should prove a good tree for underplanting old stands of that species.

In the plantations examined ash has not grown as rapidly as in natural stands. Lack of knowledge regarding the tree's requirements is probably responsible for this, and both green and white ash should be given a further trial on various kinds of soil, though it would not pay to plant them on good agricultural land. Young green ash trees are inclined to be somewhat crooked, but the timber is strong and can be used for many purposes on a farm. A valuation of $4 per cord has been put upon cordwood (Table 9), since most of the timber so classed can in fact be put to more valuable use.

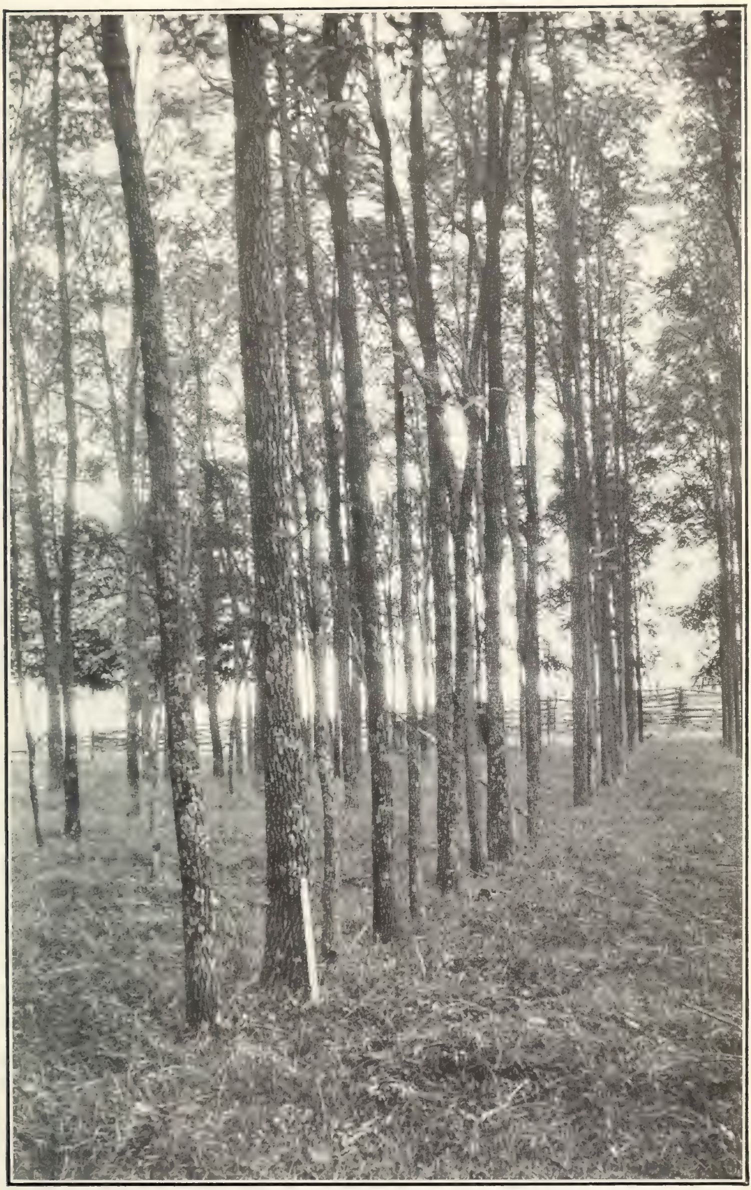
TABLE 9.—*Yield and value of green ash (Fraxinus lanceolata).*

Age.	Location	Soil.	Original spacing.	Present number of trees per acre.	Average diameter breast high.	Average height.	Yield per acre, cordwood (90 solid cu. ft.=1 cord =128 stacked cu. ft.).	Average value of land per acre during life of plantation.	Total amount of costs per acre to date.	Present value of products per acre (includes value of thinnings).	Profit (+) or loss (−) per acre.	
											Total.	Annual.
Yrs.			*Ft.*		*Ins.*	*Ft.*	*Cords.*					
17	Iowa....	Yellow clay loam.....	Broad-cast.	2,386	3.1	27	17.7	$80.00	$59.20	$70.80	+$11.60	+$0.53
20	...do.....	Black loam............	5 x 9	541	4.8	39	13.2	60.00	70.10	52.80	− 17.30	− .64
20	...do.....	.....do................	4 x 4	679	5.0	39	21.4	60.00	72.37	85.60	+ 13.23	+ .49
26	...do.....	.....do................	12 x 12	299	5.6	35	9.2	60.00	84.74	36.80	− 47.94	− 1.24
28	...do.....	.....do................	6 x 6	121	8.6	49	11.5	60.00	101.74	46.00	− 55.74	− 1.30
37	...do.....	.....do................	4 x 4	745	5.2	46	22.2	40.00	98.52	88.80	− 9.72	− .15
40	Illinois..	.....do................	(?)	283	8.5	59	39.3	80.00	219.25	157.20	− 62.05	− .18
41	Iowa....	Quite sandy loam....	1 x 4	382	6.6	49	11.5	40.00	101.74	46.00	− 55.74	− 1.30

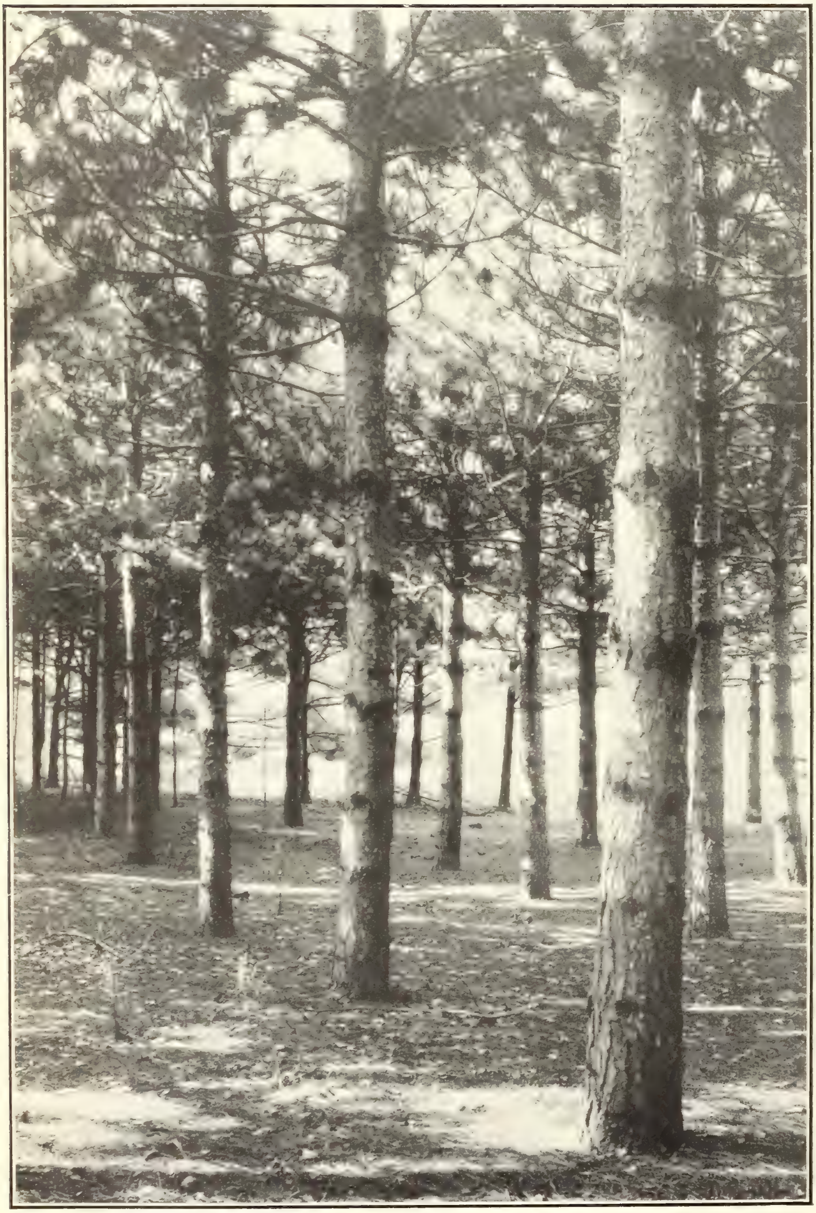
NORWAY PINE (Pinus resinosa Ait.).

Norway or red pine is especially adapted for planting on poor, sandy or gravelly soils which will not even support a good growth of white pine. On good loam soils in Iowa trees 40 years old have reached a height of from 50 to 55 feet and a diameter of 8 inches, while on very poor, sandy soil in Rhode Island and Massachusetts a height of 40 feet and a diameter of 8 to 10 inches have been attained in 40 years. Norway pine is decidely intolerant, and a spacing of 6 by 8 feet is close enough. Planting stock is usually rather expensive, because of the difficulty of obtaining seed, and the wide spacing has the additional advantage of reducing the planting costs.

Norway pine lumber is less valuable than white pine, and the production per acre is not so large, but the tree is very hardy and exceptionally free from disease. It is less subject to attack by the pine



BLACK WALNUT PLANTATION, INDIANA, 20 YEARS OLD.



NORWAY PINE PLANTATION, RHODE ISLAND, 33 YEARS OLD, VERY SANDY SOIL.

weevil, and therefore is preferable to white pine where there is danger from this insect, as in portions of New York and New England. It also does well when mixed with white pine.

RED OAK (Quercus rubra Linn.).

Largely on account of their slow rate of growth, the oaks have not been planted extensively in this country. Red oak, however, grows rather rapidly, and has much to commend it. It can be easily and cheaply propagated by planting the acorns directly on the site in the spring, after stratifying them over winter; it is hardy throughout the eastern region; it is a persistent grower after becoming established; it produces valuable material; and it is especially well fitted for growth on poor, wornout clay soils. This last fact alone makes it well worth considering. Catalpa has done poorly on some very poor, rocky, clay soils in the Middle West where red oak would doubtless have been successful. Red oak is quite tolerant, and should prove valuable for underplanting old, deteriorating stands on poor soils; also for planting in mixture with more rapid growing, intolerant trees such as European larch, or with equally rapid growing tolerant trees such as white pine. When planted pure, it should be spaced about 6 by 6 feet. A Rhode Island plantation on poor sandy soil has reached an average diameter of 9 inches and a height of 45 feet in 34 years; another plantation on good black agricultural soil in Illinois has reached an average diameter of 5 inches and a height of 38 feet in 25 years.

HARDY CATALPA (Catalpa speciosa Warder).

In gathering data for this report very little attention was given hardy catalpa plantations, because the tree has been considered in previous publications. Hardy catalpa requires for its best development a fresh, well-drained loamy soil, or a sandy river-bottom soil, where the water table is within a few feet of the surface. A spacing of from 6 by 6 feet to 6 by 8 feet is close enough. The tree grows rapidly and sprouts vigorously from the stump, thus insuring several crops from one planting. It needs cultivation and pruning, and produces material chiefly valuable for its durability in contact with the ground. The species is hardy in the Middle West as far north as central Iowa, and in Michigan near the lake shore as far north as 43° latitude. In the interior of Michigan, however, it is frozen back at this latitude. Although not yet planted extensively in New England, some young plantations in Connecticut and Rhode Island indicate that it will do well there, unless planted on the most exposed sites. On good soils in the Middle West plantations have reached a diameter of from 6 to 7 inches and a height of from 40 to 50 feet in 20 years.

Hardy catalpa gives promise of growing well on some of the poorer wornout clay soils of the Middle West, but with our present knowledge of the tree's requirements it can not yet be recommended for such sites. It is also growing on sandy upland soil in Rhode Island, but has not attained a large size there. Much catalpa has been planted under circumstances which practically insure financial loss. Agents have exaggerated the good qualities of the species, and have sold a large amount of stock at $20 to $25 per thousand, advising that it be planted on almost any soil, good or poor, which happened to be available. Prospective planters should consult their State forestry officials or the United States Forest Service.

BLACK LOCUST (Robinia pseudacacia Linn.).

Were it not for the locust borer, black locust could be recommended as one of the best trees for forest planting throughout most of the eastern region. It grows well on poor, sandy, gravelly, or clay soils, sprouts vigorously, and is hardy as far north as southern Michigan, but farther north is killed back in winter. One exceptionally good plantation in Indiana has reached a diameter of 7 inches and a height of 45 feet in 13 years. The wood is very durable in contact with the ground, and makes valuable fence posts. But on account of the likelihood of destructive attacks by the locust borer the planting of black locust for commercial purposes can not be recommended. Some plantations, it is true, have not been attacked by the insect; some localities are at present free from it; but plantations from Kansas to New England have been seriously injured, and to set out black locust to-day for commercial purposes would be a very doubtful venture.

OTHER SPECIES.

Certain other species promise well for the eastern region, although they have not all been tested to the age of maturity. Young plantations of western yellow pine are growing well on poor, rocky clay agricultural lands in Ohio and southern Michigan, and on dry, deep, sandy lands in New York, and there seems to be no reason why the species should not do fully as well in New England on similar soils. It is quite hardy and resistant to drought.

Chestnut would be an excellent tree to plant, particularly in southern New England, Pennsylvania, and parts of New York and Ohio, were it not for the very virulent fungus, *Endothia parasitica* (Murrill) Anderson, which has killed a great many trees and threatens to destroy most of the remaining stands. No practical method of combating this disease has been devised, so it is not advisable at present to start plantations of chestnut.

Yellow poplar should do well in the eastern region on moist hillsides with good, well-drained soils, or along the banks of streams. It produces valuable timber, commands a high stumpage price, and makes fairly rapid growth.

Douglas fir has been planted on poor stony soils in southern Michigan and Ohio and on poor sandy soils in Rhode Island, and so far has done very well. It is hardy and grows fairly rapidly. The Rocky Mountain or northern Idaho variety should prove to be an admirable tree for planting in the eastern region, but the Pacific Coast variety may be damaged by frost.

White spruce has lately come into favor in the Middle West as a tree for windbreaks, and would probably do as well in the northeast. It does not grow as rapidly as Norway spruce, but retains its lower foliage better, and at the age of about 40 years, when Norway spruce is likely to become ragged, is in its best condition for windbreak purposes. For this purpose it should not be spaced more closely than 12 by 12 feet. On account of its tolerance, it is well adapted for underplanting old deteriorating stands of cottonwood or maple.

TABLE 10.—*Species and methods for planting in different regions.*

Species to plant.	Soil.	Spacing.	Planting method.	Products.	Age.
		TREELESS REGION.			
					Years.
Cottonwood	Moist soil; sandy river bottom best.	15 x 15 and underplant with silver maple, or plant 2 to 4 feet apart in rows.	Plant cuttings in a furrow.	Lumber and cordwood.	30–40
Silver maple	Fresh to moist loam or sandy loam.	6 x 8	Sow seed direct	Cordwood	25–40
Green ash	Well-drained loam soil.	4 x 4	Sow seed direct or slit method.	Handle material, farm timbers.	40–50
Hardy catalpa	Well-drained loam or sandy loam.	6 x 8	Slit method	Posts	18–20
Black walnut	do	6 x 6	Sow seed direct	Lumber	50–75
European larch	do	12 x 12; fill in to a 6 x 6 spacing with white pine.	Slit method	Poles, posts	25–40
White pine	Well-drained sandy or loam soils.	6 x 6	Slit or furrow method.	Lumber	50
White spruce	Fresh to moist loam.	For windbreak 10 x 10.	do	Lumber, pulp, cordwood.	60
Norway spruce	do	do	Slit method	do	50
		HARDWOOD REGION.			
Black walnut	Well-drained black or clay loam.	6 x 6	Sow seed direct	Lumber, pulp, cordwood.	50–75
White ash	do	4 x 4	Sow seed direct or slit method.	Handle material, farm timbers.	40–50
Green ash	do	4 x 4	do	do	40–50
Hardy catalpa	do	6 x 8	Slit method	Posts	18–20
Tulip poplar	Moist loam	8 x 8	do	Lumber	40–50
White pine	Sandy soil or gravelly loam.	6 x 6	do	do	50
Red oak	do	6 x 6	Sow seed direct	do	50
		NORTHEAST REGION.			
White pine	Sandy or gravelly loam; rocky hillsides.	6 x 6	Sow seed direct; dig hole for each tree; slit method.	Lumber	50
Norway pine	Poor sandy or gravelly soils.	6 x 8	do	do	50–60
Norway spruce	Heavier loam soils.	5 x 5 to 6 x 6	Slit method; dig hole for each tree.	do	50–60
Red oak	Sandy or clay soils.	6 x 6	Sow seed direct	do	50
Yellow poplar[1]	Moist loam soil	8 x 8	Slit method	do	40–50

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[1] Yellow poplar should not be planted farther north than southern New York or southern New England.

APPENDIX.

Below are given the prices quoted for planting stock by certain nurserymen. Prices, of course, vary somewhat from year to year. Where large lots of seedlings or transplants are desired, the planter can usually secure much lower quotations by contracting for the whole lot with a reliable nursery. A list of dealers handling different species of forest trees may be obtained from the Forest Service upon request.

Prices quoted for nursery stock by nurserymen.

Variety.	Price per thousand.			
	1-year seedlings.	2-year seedlings.	3-year transplants.	Cuttings.
Silver maple	$3.00–$6.00			
Red oak	3.00– 7.00			
Black locust	2.00– 3.00			
White elm	2.00– 5.00			
Honey locust	2.50– 7.00			
Cottonwood	2.50– 5.00			$3.00
Hardy catalpa	3.00– 7.00			
Russian mulberry	3.00– 4.00			
White ash	2.50– 5.00			
White willow				$2.00–4.00
Black walnut	8.00–10.00			
Osage orange	2.00– 4.00			
Green ash	3.00– 5.00			
Yellow poplar	6.00			
Jack pine		$3.00	$6.00–$10.00	
Norway or red pine			6.00– 12.00	
Norway spruce		3.00	6.00– 12.00	
White pine		3.00	5.00– 10.00	
Scotch pine		$3.00–4.00	5.00– 10.00	
European larch		3.00–6.00	6.00	
Western yellow pine		3.50–4.00	7.00– 12.00	

The following is a list of State forest officers, who will be glad to give advice and assistance in matters relating to forestry or forest fires to those living within their respective States.

State.	Officer in charge.	Address.
Alabama	Secretary, commission of forestry	Montgomery.
California	State forester	Sacramento.
Colorado	do	Fort Collins.
Connecticut	do	New Haven.
Delaware	State board of forestry [1]	
Georgia	Professor of forestry, Georgia State forest school	Athens.
Hawaii	Superintendent of forestry	Honolulu.
Idaho	State land commissioner [2]	Boise.
Indiana	Secretary, State board of forestry	Indianapolis.
Iowa	State forestry commissioner	Des Moines.
Kansas	State forester	Manhattan.
Kentucky	do	Frankfort.
Louisiana	President, State conservation commission	New Orleans.
Maine	State forest commissioner [2]	Augusta.
Maryland	State forester	Baltimore.
Massachusetts	do	Boston.
Michigan	do	Lansing.
Do	Forest fire warden [2]	Do.
Minnesota	State forester	St. Paul.
Montana	do	Helena.
New Hampshire	do	Concord.
New Jersey	do	Trenton.

[1] Authorized by law but not yet organized.

[2] Forest fires only.

State.	Officer in charge.	Address.
New York	Superintendent of State forests	Albany.
North Carolina	Forester of State geological and economic survey	Chapel Hill.
North Dakota	State forester	Bottineau.
Ohio	do	Wooster.
Oregon	do	Salem.
Pennsylvania	Commissioner of forestry	Harrisburg.
Rhode Island	do	Chepachet.
South Dakota	Forester of the commission of school and public lands	Custer.
Tennessee	State warden of game, fish, and forestry	Nashville.
Do	Forester of State geological survey	Do.
Vermont	State forester	Burlington.
Virginia	Commissioner of agriculture	Richmond.
Do	State forester[1]	Charlottesville.
Washington	State forester and fire warden	Olympia.
West Virginia	Forest, game, and fish warden[2]	Belington.
Wisconsin	State forester	Madison.

[1] Authorized by law but not organized.

[2] Forest fires only.

The following publications of the Department of Agriculture deal with forest planting. Application for any of them should be made to the Division of Publications, Department of Agriculture.

Forest Service Bulletins.

No.
37. The Hardy Catalpa.
42. The Woodlot: Handbook for Owners of Woodlands in Southern New England.
65. Advice for Forest Planters in Oklahoma and Adjacent Regions.
76. How to Grow and Plant Conifers in the Northeastern States.
86. Windbreaks: Their Influence and Value.
121. Reforestation on the Sandhills of Nebraska and Kansas.

Forest Service Circulars.

37. Forest Planting in the Sandhill Region of Nebraska.
41. Forest Planting on Coal Lands in Western Pennsylvania.
45. Forest Planting in Eastern Nebraska.
54. How to Cultivate and Care for Forest Plantations on Semiarid Plains.
55. How to Pack and Ship Young Trees.
56. Bur Oak (*Quercus macrocarpa*).
57. Jack Pine (*Pinus divaricata*).
60. Red Pine (*Pinus resinosa*).
62. Shagbark Hickory (*Hicoria ovata*).
64. Black Locust (*Robinia pseudacacia*).
65. Norway Spruce (*Picea excelsa*).
67. White Pine (*Pinus strobus*).
68. Scotch Pine (*Pinus sylvestris*).
72. Western Yellow Pine (*Pinus ponderosa*).
73. Red Cedar (*Juniperus virginiana*).
74. Honey Locust (*Gleditsia triacanthos*).
75. Hackberry (*Celtis occidentalis*).
81. Forest Planting in Illinois.
83. Russian Mulberry (*Morus alba tartarinae*).
84. White ash (*Fraxinus americana*).
85. Slippery Elm (*Ulmus pubescens*).
86. Boxelder (*Acer negundo*).
87. White Willow (*Salix alba*).
88. Black Walnut (*Juglans nigra*).
90. Osage Orange (*Toxylon pomiferum*).
91. Coffeetree (*Gymnocladus dioicus*).

No.
92. Green Ash (*Fraxinus lanceolata*).
93. Yellow poplar (*Liriodendron tulipifera*).
95. Sugar Maple (*Acer saccharum*).
106. White Oak (*Quercus alba*).
145. Forest Planting on the Northern Prairies.
154. Native and Planted Timber of Iowa.
161. Forest Planting in Western Kansas.
182. Shortleaf Pine (*Pinus echinata*).
183. Loblolly Pine (*Pinus taeda*).
195. Forest Planting in Northeastern and Lake States.

BULLETINS OF THE DEPARTMENT OF AGRICULTURE.

11. Forest Management of Loblolly Pine in Delaware, Maryland, and Virginia.
13. White Pine under Forest Management.
24. Cottonwood in the Mississippi Valley.

FARMERS' BULLETIN OF THE DEPARTMENT OF AGRICULTURE.

622. Basket Willow Culture.

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